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BULLETIN

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TORREY BOTANICAL CLUB

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Studies of West Indian plants—VII

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39. THE GENUS SCLERIA BERG. IN CUBA

The last previous treatment of the Cuban species is that of Mr. C. B. Clarke in Urban, Symb. Ant. **2**: 8–169. 1900.

A. Hypogynium present.
1. Hypogynium not covered with a white rough crust.
a. Margin of the hypogynium neither ciliate nor fimbriate [see *S. cubensis*].
* Roots fibrous; rootstocks none or very short.
Achene reticulated or irregularly ridged; plants slender. 1. *S. setacea.*
Achene smooth; plants stout. 2. *S. lacustris.*
** Perennials, with rootstocks. [Rootstock in *S. setuloso-ciliata* short, or perhaps none.]
Achene smooth.
Ligule large, its margin scarious or callous.
Climbing; branched; pilose. 3. *S. secans.*
Erect; simple; glabrous. 4. *S. catalinae.*
Ligule short, small; culms erect or spreading.
Culms slender; leaves relatively smooth.
Panicle red-purple; achene purple to white. 5. *S. melaleuca.*
Panicle brown-green; achene white.
Achene depressed-globose. 6. *S. pterota.*
Achene longer than thick.
Leaves 2–4 mm. wide. 7. *S. Wrightiana.*
Leaves 8–15 mm. wide. 8. *S. setuloso-ciliata.*
Culms stout; leaves very rough. 9. *S. scindens.*
Achene verrucose, reticulated or papillose.
Achene papillose. 10. *S. ciliata.*

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Achene verrucose or reticulated.
Achene reticulated; hypogynium supporting 3 deeply 3-lobed tubercles. 11. *S. Curtissii.*
Achene verrucose-reticulated; hypogynium 3-lobed.
Glabrous or nearly so. 12. *S. stereorrhiza.*
Leaves and sheaths densely pilose-pubescent. 13. *S. pilosissima.*
b. Margin of the hypogynium ciliate, ciliolate or fimbriate [nearly or quite eciliate in *S. cubensis*].
Margin of the hypogynium ciliate or ciliolate.
Achene 2 mm. long or less. 14. *S. microcarpa.*
Achene 2.5–3 mm. long.
Style-base black, persistent; achene ellipsoid. 15. *S. mitis.*
Style-base pale, deciduous; achene subglobose.
Leaves about 3 mm. wide. 16. *S. phylloptera.*
Leaves 8–16 mm. wide.
Margin of the hypogynium ciliolate or eciliate. 17. *S. cubensis.*
Margin of the hypogynium densely long-ciliate. 18. *S. Grisebachii.*
Margin of the hypogynium 3-lobed, the lobes laciniate or fimbriate. 19. *S. porphyrorrhiza.*
2. Hypogynium covered with a white rough crust. 20. *S. havanensis.*
B. Hypogynium none, or obsolete.
Annuals with fibrous roots; inflorescence glomerate-spicate.
Achene smooth. 21. *S. distans.*
Achene verrucose, reticulated or cancellate.
Bracts strongly ciliate; achene cancellate. 22. *S. pinetorum.*
Bracts glabrous; achene verrucose or verrucose-reticulated.
Inflorescence simply glomerate-spicate. 23. *S. verticillata.*
Inflorescence branched. 24. *S. Liebmanni.*
Perennial by rootstocks.
Inflorescence glomerate-spicate; achene smooth. 25. *S. hirtella.*
Inflorescence not glomerate-spicate.
Panicle loose. 26. *S. lithosperma.*
Inflorescence subcapitate.
Achene 2–3 mm. long, with 2 pits on each side of the 3-angled base. 27. *S. gracilis.*
Achene 4 mm. long, without pits. 28. *S. Baldwinii.*

1. SCLERIA SETACEA Poir. in Lam. Encycl. **7**: 4. 1806

Scleria hemitaphra Steud. Syn. Pl. Cyp. 169. 1855.

Scleria Torreyana Walp. Ann. **3**: 696. 1853.

Scleria dictyocarpa Griseb. Cat. Pl. Cub. 259. 1866.
Scleria debilis C. Wright; Sauvalle, Anales Acad. Habana 8: 154. 1872.
S. reticularis pubescens Britton, Ann. Lyc. N. Y. 3: 232. 1885.

Savannas and along streams, Pinar del Rio:—southern United States; Porto Rico; tropical continental America.

2. SCLERIA LACUSTRIS C. Wright; Sauvalle, Anales Acad. Habana 8: 152. 1872

Lagoons near Pinar del Rio. Recorded by Clarke from French Guiana and from Java.

3. SCLERIA SECANS (L.) Urban, Symb. Ant. 2: 169. 1900

Schoenus secans L. Syst. ed. 10, 865. 1759.
Scleria reflexa HBK. Nov. Gen. 1: 232. 1815.

Mountain woodlands, Oriente:—Haiti to Martinique and Trinidad; Jamaica; tropical continental America.

My examination of the type specimen of *Schoenus secans* L., in the herbarium of the British Museum of Natural History, some years ago, showed that it was the same as *Scleria reflexa* HBK., and not the same as *Scleria Flagellum-nigrorum* Berg.

4. **Scleria catalinae** sp. nov.

Perennial by thick rootstocks; culm stout, sharply 3-angled, roughish on the angles, glabrous, about 1.3 m. high. Leaves glabrous, slightly roughish-margined, 3–5 dm. long, 1–2.3 cm. wide, 3-nerved, attenuate-acuminate, the ligule triangular-ovate to triangular-lanceolate, acute or acuminate, many-striate, narrowly callous-margined, 2 cm. long or less; panicle about 5 dm. long, of few, distant, slender branches, the staminate and pistillate spikelets intermixed; staminate spikelets oblong, 3–4 mm. long; achene ovoid, purplish, smooth, shining, acute, 2 mm. long, the style-base persistent; hypogynium obconic, 1 mm. long, glabrous, its base rounded, its 3 rounded lobes appressed.

Santa Catalina, Pinar del Rio (*Van Hermann 3272*).

By its very large ligule related to *S. arundinacea* Kunth, but the achene and inflorescence are quite different, resembling those of *S. cubensis* Boeckl.

5. SCLERIA MELALEUCA Schl. & Cham. Linnaea **6**: 29. 1831

Savannas and banks, Camaguey; Havana; Pinar del Rio:—Jamaica; Porto Rico; St. Vincent to Trinidad; continental tropical America. The West Indian specimens here referred are not very different from the following species.

6. SCLERIA PTEROTA Presl in Oken, Isis **21**: 268. 1828

Scleria pratensis Nees in Mart. Fl. Bras. **2**[1]: 179. 1843.
Scleria Ottonis Boeckl. Linnaea **38**: 490. 1874.

Woodlands and banks, Santa Clara; Havana; Pinar del Rio; Isle of Pines:—Haiti to St. Thomas and Barbadoes; Jamaica; continental tropical America.

7. SCLERIA WRIGHTIANA Boeckl. Flora **64**: 79. 1881

Scleria elata C. Wright; Sauvalle, Anales Acad. Habana **8**: 153. 1872. Not Thwaites.

Pine-lands and savannas, Pinar del Rio and Isle of Pines. Endemic.

8. SCLERIA SETULOSO-CILIATA Boeckl. Flora **65**: 30. 1882

Wet situations, Matanzas; Havana; Isle of Pines:—Guatemala.

9. SCLERIA SCINDENS Nees, Linnaea **9**: 303. 1834

Mountain woodlands, Oriente:—Tortola; St. Kitts to St. Vincent.

10. SCLERIA CILIATA Michx. Fl. Bor. Am. **2**: 167. 1803

Scleria Elliottii Chapm. Fl. S. U. S. 531. 1860.

Barrens and pinelands, Santa Clara; Matanzas; Pinar del Rio; Isle of Pines:—southeastern United States; Santo Domingo.

11. SCLERIA CURTISSII Britton; Small, Fl. S. E. U. S. 200, 1328. 1903

? *Scleria pauciflora effusa* Clarke in Urban, Symb. Ant. **2**: 143. 1900.

Savannas, Pinar del Rio and Isle of Pines:—Florida. Referred by Wright, by Clarke and formerly by me to *S. pauciflora* Muhl.

12. SCLERIA STEREORRHIZA C. Wright; Clarke in Urban, Symb. Ant. **2**: 147. 1900

Scleria bracteata Griseb. Cat. Pl. Cub. 249. 1866. Not Cav.

Scleria bracteata angustata Griseb. *loc. cit.* 1866.

Scleria stereorrhiza major Clarke in Urban, *loc. cit.* 1900.

Along streams and on hillsides, Santa Clara; Havana; Pinar del Rio. Endemic.

13. **Scleria pilosissima** sp. nov.

Perennial by short, branched rootstocks; culms rather slender, but stiff, sharply 3-angled, loosely pilose, simple, 3–4 dm. high. Leaves roughish-margined, 1–2 dm. long, 2–4 mm. wide, acuminate, stiff, densely pilose, the midvein prominent beneath; clusters of spikelets 1 or 2, pilose, 2–4 cm. long, the staminate and pistillate spikelets intermixed; scales lanceolate, acute, pubescent; achene subglobose, 2–2.5 mm. in diameter, transversely verrucose, pubescent, obtuse, abruptly apiculate; hypogynium with 3 rounded, appressed lobes.

Sunny hillsides among rocks, between Punta Gorda and Woodfred, Oriente, Cuba, 400–500 m. alt. (*Shafer 3099*).

Related to *S. stereorrhiza* C. Wright.

14. SCLERIA MICROCARPA Nees, Linnaea **9**: 302. 1834

Scleria foliosa C. Wright; Sauvalle, Anales Acad. Habana **8**: 154. 1872. Not A. Rich.

Scleria microcarpa foliosa Clarke in Urban, Symb. Ant. **2**: 149. 1900.

River banks, Pinar del Rio and Isle of Pines:—Porto Rico; Guadaloupe; Jamaica; Trinidad; continental tropical America.

15. SCLERIA MITIS Berg. Vet. Akad. Handl. Stockh. **26**: 145. 1865

Scleria Eggersiana Boeckl. Cyp. Nov. **2**: 41. 1890.

Pinal de Sta. Ana collected by Eggers, according to Clarke:—Porto Rico; Guadeloupe; Martinique; St. Vincent; Trinidad: continental tropical America.

16. SCLERIA PHYLLOPTERA C. Wright; Griseb. Cat. Pl. Cub. 248. 1866

Scleria microcarpa angustifolia Boeckl. Flora **64**: 79. 1881.

Moist savannas and borders of lagoons, Santa Clara; Pinar del Rio. Endemic.

17. SCLERIA CUBENSIS Boeckl. Cyp. Nov. **2**: 42. 1890

Scleria microcarpa subeciliata Clarke in Urban, Symb. Ant. **2**: 149. 1900

Banks and woodlands, mountains of Oriente and Santa Clara:—Hispaniola; Porto Rico; Jamaica.

18. SCLERIA GRISEBACHII Clarke in Urban, Symb. Ant. **2**: 150. 1900

Bogs, Santa Clara; Havana:—Hispaniola; Antigua; Dominica; Martinique; Jamaica.

19. SCLERIA PORPHYRORRHIZA C. Wright; Sauvalle, Anales Acad. Habana **8**: 155. 1872

Pinelands, Pinar del Rio. Recorded by Clarke from Brazil.

20. **Scleria havanensis** sp. nov.

Rootstocks stout, horizontal, 3–4 cm. long, about 6 mm. thick. Culms many, slender, trigonous, nearly smooth, about 5 dm. long; leaves nearly smooth, narrow, 1–1.5 mm. wide; inflorescence a single small cluster of intermixed staminate and pistillate spikelets; achene white, ridged-reticulated, globose-oblong, rounded, 2 mm. long; hypogynium low, obscurely 3-lobed, covered with a rough whitish crust.

Coca Hill, Campo Florida, province of Havana (*Brother Leon 4731*).

21. SCLERIA DISTANS Poir. in Lam. Encycl. **7**: 4. 1806

Scleria tenella Griseb. Cat. Pl. Cub. 249, in part. 1866. Not Kunth.

? *S. hirtella pauciliata* Britton, Ann. N. Y. Acad. Sci. **3**: 236. 1885.

Cuba, collected by Wright:—Hispaniola; Porto Rico; St. Thomas; Guadeloupe.

22. **Scleria pinetorum** sp. nov.

Annual, with many finely fibrous roots; culms slender, erect, 2–4 dm. high. Leaves grass-like, pubescent with spreading hairs, 1–2 mm. wide; inflorescence glomerate-spicate, 5–8 cm. long;

bracts linear-lanceolate, ciliate, 6 mm. long or less; achene globular, white, deeply reticulated, about 1.5 mm. in diameter, with a row of pits at its base, the short base 3-angled.

Pine-lands and savannas, Pinar del Rio. Type collected between Candelaria and Artemisa (*Wilson 1724*).

Previously referred by me (Ann. N. Y. Acad. Sci. 3: 236) to *S. interrupta* A. Rich., of Guiana, which now seems to me to be distinct.

23. SCLERIA VERTICILLATA Muhl.; Willd. Sp. Pl. 4: 317. 1805

Pinelands, Pinar del Rio; Isle of Pines:—eastern United States; New Providence, Bahamas.

24. SCLERIA LIEBMANNI Steud. Syn. Pl. Cyp. 179. 1855

Scleria tenella Griseb. Cat. Pl. Cub. 249, in part. 1866. Not Kunth.

Scleria luzulaeformis C. Wright; Sauvalle, Anales Acad. Habana 8: 156. 1872.

Savannas near San Juan de Buena Vista, jurisdiction of Bayamo, according to Sauvalle (*Wright 3418*, in part); Mexico to Brazil.

25. SCLERIA HIRTELLA Sw. Prodr. 19. 1788

Scleria nutans Kunth, Enum. 2: 352. 1837.

Moist grounds, Oriente; Santa Clara; Pinar del Rio; Isle of Pines,—southern United States; Haiti; Porto Rico; Jamaica; Trinidad; continental tropical America; tropical Africa.

26. SCLERIA LITHOSPERMA (L.) Sw. Prodr. 18. 1788

Scirpus lithospermus L. Sp. Pl. 51. 1753.

Scleria filiformis Sw. Prodr. 19. 1788.

S. lithosperma filiformis Britton, Ann. N. Y. Acad. Sci. 3: 231. 1885.

Woodlands and thickets, all provinces:—Florida; Bahamas; West Indies; tropical continental America; Old World tropics.

27. SCLERIA GRACILIS Ell. Bot. S. C. & Ga. 2: 571. 1824

Moist savannas, Pinar del Rio:—southeastern United States.

28. SCLERIA BALDWINII (Torr.) Steud. Syn. Pl. Cyp. 175. 1855

Hypoporum Baldwinii Torr. Ann. Lyc. N. Y. 3: 382. 1836.

Border of lagoon, Laguna Santa Maria, Pinar del Rio:—southeastern United States.

FURTHER STUDIES OF BADIERA DC.

Since the publication of my former paper on this genus (Bull. Torrey Club **37**: 360–363. 1910), additional specimens which have come to hand afford the following notes and descriptions.

1. BADIERA PENAEA (L.) DC.

Professor Urban has informed me that my opinion that this is identical with *Badiera domingensis* (Jacq.) DC. is correct, although he has distributed Santo Domingo specimens under the name *B. domingensis*.

1*a*. **Badiera portoricensis** sp. nov.

A tree up to 6 m. high, the trunk sometimes 1.5 m. in diameter, the slender branches ascending, the young twigs appressed-pubescent. Leaves subcoriaceous, obovate, 3 cm. long or less, 7–15 mm. wide, bright green and shining above, paler and rather dull green beneath, both surfaces with short, scattered hairs when young, becoming glabrate above, the midvein slightly impressed above, rather prominent beneath, the lateral veins few, distant, obscure, the apex rounded or obtuse, the base narrowed or cuneate, the pubescent petioles 1–2.5 mm. long; inflorescence few–several-flowered, 4–6 mm. long; bracts ovate or ovate-lanceolate, acute, pubescent, 0.5 mm. long; pedicels appressed-pubescent, 1.5–2.5 mm. long; sepals broadly ovate, obtuse, ciliolate, the larger about 1 mm. long; petals white; keel appressed-pubescent, 2 mm. long, narrowed below; fruit about 6 mm. wide, about 5 mm. high, finely pubescent, narrowly margined, notched at the apex, subtruncate at the base, its stipe about 0.6 mm. long.

Rocky slopes and hillsides, western Porto Rico, especially on serpentine, from sea-level to 700 m. altitude. Type collected at Guanajibo, near Mayaguez (*Britton, Cowell & Brown 4349*). Recorded by Bello from my type locality as *B. domingensis* DC. [*Polygala domingensis* Jacq.; *B. Penaea* (L.) DC.] of Hispaniola, to which species it is nearest related, but which differs in pilose-pubescent twigs, rather densely pubescent leaves, and much more pubescent, shorter-pedicelled flowers.

2. BADIERA VIRGATA Britton

The specimen referred to by me under *B. oblongata* Britton (*Britton & Wilson 6066*) from Santa Clara, Cuba, is now, in the light of additional material, put with *B. virgata*, as a broad-leaved race.

4. BADIERA DIVERSIFOLIA (L.) DC.

This, the only Jamaican species of the genus, forms a tree up to 6 m. high, as at St. Ann's Bay (*Britton 2498*).

5. BADIERA CUBENSIS Britton

In the original description of this species (Bull. Torrey Club **37**: 362), I included too many citations of specimens. C. Wright's Cuban *1913* consists, apparently, of three species; it is to the specimen with abruptly acuminate leaves cuneate-narrowed at the base, 4–6 cm. long, that the name should be restricted. As shown by specimens from Bahia Honda, Pinar del Rio (*P. Wilson 9429*) the leaves vary to obovate. The fruit is glabrous when mature, its slender stipe 2 mm. long.

5*a*. BADIERA FUERTESII Urban, Symb. Ant. **7**: 244. 1912

A tree of the mountains of Santo Domingo, with glabrous leaves, strongly reticulate-veined on the upper surface.

6. BADIERA MONTANA Britton

Described from fruiting specimens collected in the Trinidad Mountains, Santa Clara, Cuba. Flowering specimens with apparently the same foliage and pubescence come from limestone hills in the vicinity of Sumidero, Pinar del Rio (*Shafer 13819*), but flowers from the Trinidad Mountain tree are needed to make the identity wholly satisfactory.

8. **Badiera propinqua** sp. nov.

Twigs slender, densely appressed-pubescent. Leaves ovate to ovate-elliptic, 2–4.5 cm. long, 8–25 mm. wide, bluntly acute or obtuse and emarginate at the apex, narrowed or obtuse at the base, sparingly short-pubescent on both sides or becoming glabrous, the midvein impressed above, prominent beneath, the slender lateral veins 6 to 8 on each side of the midvein, the appressed-pubescent petioles 1.5–3 mm. long; inflorescence few-flowered,

4–5 mm. long; bracts ovate, densely pubescent, scarcely 0.5 mm. long; pedicels slender, appressed-pubescent, 1.5–2.5 mm. long; sepals suborbicular, rounded, pubescent, the larger about 1.3 mm. long; petals white; keel pubescent on the sides, about 2.5 mm. long; fruit (from *Wright 1913, in part*) 10 mm. wide, 7 mm. long, deeply notched, scarcely margined, glabrous, decurrent on its stipe, which is about 2 mm. long.

Cuba. Type collected between Los Palacios and San Juan de Zayas, Pinar del Rio (*Shafer 11818*). The description is drawn to include the part of *Wright 1913*, and *Wright 3496*, previously referred by me to *B. cubensis*. The part of *Wright 115*, included by me in the original description of *B. cubensis*, is perhaps referable here also.

9. **Badiera punctata** sp. nov.

A shrub about 1 m. high, with slender, ascending, or nearly erect branches, the twigs densely appressed-pubescent with short hairs. Leaves ovate to ovate-elliptic, firm in texture, 1.5–2.5 cm. long, 12 mm. wide or less, obtuse or emarginate at the apex, obtuse at the base, the midvein impressed above, prominent beneath, the lateral veins 3 or 4 on each side, the upper surface strongly punctate, shining and glabrous or nearly so, the under surface dull, the petioles about 1.5 mm. long; inflorescence few-flowered; bracts scarcely 0.5 mm. long; fruiting pedicels slender, nearly glabrous, 2–2.5 mm. long; sepals ovate, obtuse, ciliate, about 1 mm. long; fruit (not quite mature) "green and red," 7 mm. wide, about as long as wide, shallowly notched at the apex, obliquely subtruncate at the base, narrowly margined, slightly pubescent, its stipe 1–1.5 mm. long.

Near a stream, Arroyo del Medio above the falls, Oriente, Cuba (*Shafer 3644*). The leaves droop at night, a phenomenon also observed in *B. virgata*.

10. **Badiera heterophylla** sp. nov.

An upright shrub 6 dm. high, the twigs short-pubescent with somewhat spreading hairs. Leaves of two quite different forms, (1) narrowly ovate, 3–4 cm. long, 12–18 mm. wide, bluntly acute at the apex, (2) elliptic, 2–2.5 cm. long, 12–14 mm. wide, rounded or obtuse at the apex; both forms emarginate at the apex, narrowed or obtuse at the base, sparingly short-pubescent and dull on both sides, the midvein impressed above, prominent beneath, the slender lateral veins only 2 or 3 on each side of the midvein,

the appressed-pubescent petioles about 2 mm. long; inflorescence about 5 mm. long; bracts about 0.5 mm. long; pedicels pubescent, 2 mm. long or less; sepals rounded, pubescent, the larger about 1 mm. long; "flowers yellow"; petals slightly pubescent in the bud; fruit 7–8 mm. wide, about 5 mm. high, margined, rather deeply notched, sparingly pubescent when young, glabrous when mature, slightly decurrent on its stipe which is about 1.5 mm. long.

Deciduous woods, Sierra Nipe, near Woodfred, Oriente, at 450–550 m. altitude (*Shafer 3070*).

40. THE GENUS TRICERA Sw. IN CUBA

1. Styles coherent, at least at the base.
   Leaves oblong to oblong-lanceolate, 2–3 cm. wide; styles coherent below. 1. *T. Muelleriana.*
   Leaves broadly ovate to ovate-lanceolate, 5 cm. wide or less; styles coherent nearly throughout. 2. *T. marginalis.*
2. Styles separate and distinct.
   * Leaves 4–10 cm. long.
      Venation of the leaves manifest.
         Leaves broadly ovate, subcordate. 3. *T. cubana.*
         Leaves lanceolate to elliptic or obovate, narrowed at the base.
            Capsule globose-ellipsoid. 4. *T. acuminata.*
            Capsule ovoid, acute. 5. *T. brevipes.*
      Venation of the leaves obsolete or indistinct.
         Petioles very stout, 10 mm. long or less; leaves very thick. 6. *T. crassifolia.*
         Petioles slender, 2–6 mm. long; leaves firm, but not very thick.
            Twigs yellow. 7. *T. flaviramea.*
            Twigs green.
               Capsule-lobes semiovate. 8. *T. retusa.*
               Capsule-lobes linear-spatulate. 9. *T. gonoclada.*
   ** Leaves 1–3.5 cm. long.
      Leaves suborbicular to obovate or elliptic, not more than twice as long as wide.
         Inflorescence and capsule glabrous. 10. *T. rotundifolia.*
         Inflorescence and capsule pubescent. 11. *T. Shaferi.*
      Leaves oblong to linear-oblanceolate, 2–5 times as long as wide.
         Leaves oblong, 2–3 times as long as wide.
            Leaves densely imbricated, less than 1 cm. long, the internodes very short. 12. *T. vaccinoides.*
            Leaves not densely imbricated, 1.5–3.5 cm. long.
               Staminate flowers sessile or very nearly so. 13. *T. glomerata.*
               Staminate flowers manifestly pedicelled.
                  Leaves 2–3.5 cm. long, the lateral venation obsolete. 14. *T. bahamensis.*

Leaves 1–1.5 cm. long, the lateral venation wholly obscure. 15. *T. microphylla.*
Leaves linear-oblanceolate or linear-oblong, 4–5 times as long as wide.
Capsule glabrous. 16. *T. Leoni.*
Capsule pubescent.
Leaves strongly revolute-margined, abruptly mucronate. 17. *T. revoluta.*
Leaves scarcely revolute-margined, acute or obtuse. 18. *T. foliosa.*

1. **Tricera Muelleriana** (Urban)

Buxus Muelleriana Urban, Symb. Ant. **5**: 400. 1908.

TYPE LOCALITY: Cuba.

DISTRIBUTION: Known only from the type specimens (*C. Wright 1920*).

Referred by Grisebach to *Tricera laevigata* Sw., of Jamaica, and by Mueller to *Buxus subcolumnaris* Muell. Arg. = **Tricera subcolumnaris** (Muell. Arg.) Britton, of Martinique.

2. **Tricera marginalis** sp. nov.

A glabrous shrub about 3 m. high. Leaves broadly ovate to ovate-lanceolate, subcoriaceous, 4–8 cm. long, 2–5 cm. wide, reticulate-veined on both sides, with 2 distinct veins 1.5–3 mm. from the margins, the midvein impressed above, prominent beneath, the apex acute, the base obtuse or subtruncate, the rather slender petioles 1 cm. long or less; cymes several-flowered, longer than the petioles, glabrous; bracts ovate-lanceolate, acute, 1.5 mm. long; pedicels of the staminate flowers about 4 mm. long, the white calyx about 3 mm. long, its segments oblong, obtuse; stamens about as long as the calyx, the filaments about twice as long as the anthers; ovary ovoid; united styles somewhat longer than the ovary; stigmas recurved, about one-third as long as the styles.

Alluvial valley of Rio Yamaniguey, Oriente (*Shafer 4226*).

3. TRICERA CUBANA A. Rich. in Sagra, Hist. Cub. **11**: 217. *pl. 71.* 1845

Buxus cubana Baill. Mon. Bux. 71. 1859.

TYPE LOCALITY: Monte Libau, Oriente.

ILLUSTRATION: A. Rich. *loc. cit.*

DISTRIBUTION: Known only from the type locality.

4. **Tricera acuminata** Griseb. Nachr. Gesell. Wiss. Goetting. **1865**: 162. 1865

Buxus acuminata Muell. Arg. in DC. Prodr. **16**[1]: 15. 1869.

TYPE LOCALITY: Cuba.

DISTRIBUTION: Known only from the type specimens (*C. Wright 1919*, in part).

5. **Tricera brevipes** (Muell. Arg.)

Buxus citrifolia brevipes Muell. Arg. in DC. Prodr. **16**[1]: 15. 1869.
Buxus brevipes Urban, Symb. Ant. **5**: 400. 1908.

TYPE LOCALITY: Cuba (*C. Wright 1919*, in part).

DISTRIBUTION: the label with *Wright 1919* in the herbarium of the New York Botanical Garden gives the locality as San Diego de Tapis; the following specimens appear to agree with it: upper valley of the Rio Navas, Oriente (*Shafer 4402*); Rio San Miguel below Mal Paso, Pinar del Rio (*P. Wilson 9309*).

Referred by Grisebach to *T. fasciculata* Griseb., of Jamaica. I am not confident that the species is distinct from *T. acuminata*.

6. **Tricera** (?) **crassifolia** sp. nov.

A glabrous shrub about 3 m. high, the twigs stout. Leaves elliptic-obovate, 6–10 cm. long, 2.5–4 cm. wide, very thick, obtuse or emarginate and mucronulate at the apex, narrowed at the base, the midvein impressed above, prominent beneath, the lateral venation faint and obscure, the stout petioles about 1 cm. long; young inflorescence axillary, about as long as the petioles, both staminate and pistillate flowers apparently sessile, the staminate about 2 mm. long.

Between Camp Toa and Camp La Barga, 400–450 m. alt., mountains of northern Oriente (*Shafer 4163*).

7. **Tricera flaviramea** sp. nov.

A glabrous shrub, 1 m. high, the young twigs and leaves yellowish green, the branches slender, somewhat ridged. Leaves elliptic or elliptic-obovate, coriaceous, revolute-margined, 3–5 cm. long, 1–2 cm. wide, rounded and minutely apiculate or emarginate at the apex, narrowed at the base, the midvein impressed above, rather prominent beneath, the lateral venation obsolete, or faintly discernible on the upper surface, the petioles 1.5–3 mm. long; inflorescence glabrous, about 1 cm. long; bracts ovate, acute, 1.5

mm. long; young staminate flowers about 2 mm. long, on pedicels about as long; capsule ovoid, obtuse, glabrous, 7–8 mm. long, 5–6 mm. thick, the persistent styles somewhat recurved, linear, 5 mm. long, separated from each other about 1 mm. at the base.

Palm-barren, Santa Clara City, Santa Clara (*Britton & Cowell 13324*, type; *Britton & Wilson 6211*).

8. TRICERA RETUSA Griseb. Nachr. Ges. Wiss. Goetting. **1865**: 163. 1865

Buxus retusa Muell. Arg. in DC. Prodr. **16**[1]: 17. 1869.

TYPE LOCALITY: Monte Verde, Oriente.

DISTRIBUTION: Mountains of northern Oriente.

9. TRICERA GONOCLADA C. Wright; Griseb. Cat. Pl. Cub. 282. 1866

Buxus gonoclada Muell. Arg. in DC. Prodr. **16**[1]: 16. 1869.

TYPE LOCALITY: Savanna near Guamacaro, western Cuba.

DISTRIBUTION: Known only from the type locality.

10. **Tricera rotundifolia** sp. nov.

A glabrous shrub, 6 dm. high, much branched, the internodes mostly shorter than the leaves. Leaves suborbicular to obovate, coriaceous, 2 cm. long or less, rounded and mucronulate or slightly emarginate at the apex, narrowed at the base, the margins thickened and somewhat revolute, the midvein rather prominent beneath, the lateral venation obsolete, the petioles 1.5–2 mm. long; inflorescence glabrous, few-flowered, in the uppermost axils; pedicels of the staminate flowers about 3 mm. long; bracts ovate, acute, 1 mm. long; staminate flowers 1.5 mm. long, their segments oblong-lanceolate, acute; capsule ovoid, about 6 mm. long, glabrous, the persistent styles contiguous, about 2 mm. long.

Between Camp La Barga and Camp San Benito, about 1,000 m. alt., northern Oriente (*Shafer 4114*).

11. **Tricera Shaferi** sp. nov.

A much-branched shrub up to 3 m. high, the twigs slender, glabrous, the internodes shorter than the leaves. Leaves obovate to elliptic, coriaceous, 1.5–3.5 cm. long, rounded or retuse at the apex and minutely mucronulate, narrowed or obtuse at the base, the midvein impressed above, prominent beneath, the lateral venation wholly obscure, the upper surface shining, dark green,

the under surface dull and pale, the petioles 1–3 mm. long; inflorescence axillary, puberulent, short-stalked, much shorter than the leaves; bracts ovate, acute, about 0.5 mm. long; pedicels of the staminate flowers rather stout, 2–3 mm. long; staminate flowers about 1.5 mm. long; capsule subglobose, densely puberulent, about 4 mm. in diameter, the separated persistent styles about 2 mm. long.

Wet mountains of northern Oriente. Type collected between Camp Toa and Camp La Barga, 400–450 m. alt. (*Shafer 4167*).

12. **Tricera vaccinioides** sp. nov.

A low, glabrous, much-branched shrub, 3–6 dm. high, the branches stout, the twigs erect-ascending, densely leafy, the internodes 3–6 mm. long. Leaves oblong to oblong-obovate, 5–8 mm. long, about twice as long as wide, coriaceous, faintly 3-veined, the secondary venation almost wholly obscure, the apex acute and mucronate, the base narrowed, the stout petioles scarcely 1 mm. long; inflorescence terminal, glabrous, few–several-flowered; pedicels of the staminate flowers rather stout, rigid, about 2 mm. long; bracts lanceolate; staminate flowers about 1 mm. long; capsule globose-ovoid, glabrous, dull, about 6 mm. long, about three times as long as the persistent styles.

Stony pass, between Camp La Barga and Camp San Benito, mountains of northern Oriente, Cuba, about 1000 m. alt. (*Shafer 4122*).

13. TRICERA GLOMERATA Griseb. Mem. Am. Acad. II. **8**: 157. 1860

Buxus glomerata Muell. Arg. in DC. Prodr. **16**[1]: 17. 1869.

TYPE LOCALITY: Cuba.

DISTRIBUTION: Dry rocky hillsides, Oriente; Santa Clara. This is a shrub up to 3 m. high, abundant near the mouth of Cienfuegos Bay; I am indebted to Professor Fernald for a comparison of a specimen collected there, at Castillo de Jagua (*Britton, Wilson & Earle 4597*), with the specimen of C. Wright in the Gray Herbarium; he pronounced it "a perfect match."

14. TRICERA BAHAMENSIS (Baker) Britton, Bull. N. Y. Bot. Gard. **4**: 139. 1906

Buxus bahamensis Baker in Hook. Ic. Pl. *pl. 1806*. 1889.

TYPE LOCALITY: Long Cay, Bahamas.

DISTRIBUTION: Cayo Romano, Camaguey:—Bahamas; Jamaica. Closely related to **Tricera Vahlii** (Baill.) Britton [*Buxus Vahlii* Baill.] of Porto Rico and St. Croix.

15. TRICERA MICROPHYLLA Griseb. Nachr. Ges. Wiss. Goetting. **1865**: 163. 1865

Buxus Wrightii Muell. Arg. in DC. Prodr. **61**[1]: 17. 1869.

TYPE LOCALITY: Western Cuba.

DISTRIBUTION: Known only from the type specimens collected by Wright.

16. **Tricera Leoni** sp. nov.

A shrub, or small tree, up to 4 m. high, glabrous throughout, the slender twigs densely leafy. Leaves linear to linear-oblong, coriaceous, shining, 2 cm. long or less, 2–4 mm. wide, spinulose-acute at the apex, narrowed at the base, the midvein faintly distinguishable above, rather prominent beneath, the lateral venation wholly obscure, the petioles 1–1.5 mm. long; inflorescence terminal, short-stalked; bracts ovate, acute, about 1 mm. long; pedicels of the staminate flowers 1.5–2 mm. long; staminate perianth-segments oblong-lanceolate, acute, 2–2.5 mm. long, filaments a little longer than the anthers; capsule globose-oblong; glabrous, 3 mm. long, the separated, persistent styles 2 mm. long.

Hill north of Monte Catalina, northeast of San Diego de los Banos, Pinar del Rio (*Brothers Leon & Charles 4874*, type); barren specimens from the southern slope of Monte Cajálbana, Pinar del Rio (*Brothers Leon & Charles 4943*), with narrower leaves than the type, are provisionally referred to the same species.

17. **Tricera revoluta** sp. nov.

A much-branched shrub, 3–10 dm. high, the twigs densely leafy, the internodes only 1–2 mm. long. Leaves linear-oblanceolate, coriaceous, 12–20 mm. long, 3–5 mm. wide, strongly revolute-margined, sharply cuspidate-mucronate at the apex, attenuate at the base, the midvein elevated beneath, the venation otherwise wholly obscure, the petioles about 2 mm. long; inflorescence few-flowered in the upper axils, pubescent; staminate flowers nearly 2 mm. long, and nearly as long as their stout pedicels; capsule subglobose, 5–6 mm. long, pubescent, shorter than the persistent, separated styles.

Dry, rocky situations, serpentine hills near mouth of Rio Yamaniguey, Oriente (*Shafer 4247*, type); between Camp La

Barga and Camp San Benito, about 1,000 m. alt., Oriente (*Shafer 4472*).

18. **Tricera foliosa** sp. nov.

A low, much-branched shrub, the slender twigs densely leafy. Leaves linear-oblanceolate, subcoriaceous, glabrous, 10–15 mm. long, 2 mm. wide or less, obtuse and often minutely mucronulate at the apex, long-attenuate to the base, the midvein impressed above, slightly elevated and channeled beneath, the lateral venation wholly obscure, the margins slightly or scarcely revolute, the petioles 1–2 mm. long; inflorescence axillary, shorter than the leaves; staminate flowers white, about 1.5 mm. long, as long or longer than their pubescent petioles; bracts lanceolate, about 1 mm. long; capsule subglobose, densely and finely pubescent, about 3 mm. in diameter, the separated persistent styles about 2 mm. long.

Among rocks near water, Camp La Gloria, south of Sierra Moa, Oriente (*Shafer 8256*, type); on rocks, vicinity of Camp San Benito, Oriente (*Shafer 4073*).

41. THE GENUS PLUMIERA L. IN CUBA

Leaves narrowly linear, 1.7 mm. wide or less. 1. *P. filifolia.*
Leaves oblong to elliptic-oblanceolate or obovate, 1–8 cm. wide.
  Leaves densely lanate or pubescent beneath.
    Corolla-lobes narrowly obovate. 2. *P. sericifolia.*
    Corolla-lobes broadly elliptic-obovate. 3. *P. lanata.*
  Leaves glabrous, or sparingly pubescent beneath.
    Petioles short, 1 cm. long or less.
      Leaves obovate or oblanceolate, the lateral venation obscure. 4. *P. clusioides.*
      Leaves narrowly oblong, the lateral venation prominent. 5. *P. nipensis.*
    Petioles slender, mostly 2–4 cm. long.
      Leaves glabrous beneath, their margins not involute.
        Corolla-lobes 2.5–3.5 cm. long, 1–1.5 cm. wide; venation widely spreading. 6. *P. emarginata.*
        Corolla-lobes 1.5–2.5 cm. long.
          Venation of the leaves ascending, not prominent beneath; corolla-lobes obovate. 7. *P. obtusa.*
          Venation of the leaves widely spreading, prominent beneath; corolla-lobes oblong-oblanceolate. 8. *P. venosa.*
      Leaves pubescent on the veins beneath, their margins involute. 9. *P. trinitensis.*

1. PLUMIERA FILIFOLIA Griseb. Mem. Am. Acad. II. **8**: 519. 1862

River cliffs, foothills of the Sierra Maestra, Nouvelle Sophie and Ensenada de Mora, Oriente. Endemic.

2. PLUMIERA SERICIFOLIA C. Wright; Griseb. Cat. Pl. Cub. 171. 1866

P. emarginata sericifolia Maza, Anales Soc. Esp. Hist. Nat. **23**: 273. 1894.

Coastal thickets, Oriente; Matanzas; Havana; Pinar del Rio: —Inagua.

Perhaps, as suggested by Professor Gomez de la Maza, a pubescent race of *P. emarginata* Griseb., which has a similar distribution in western Cuba, although I have not seen the two growing in close proximity.

3. **Plumiera lanata** sp. nov.

A shrub or small tree up to 3.3 m. high. Leaves broadly elliptic to elliptic-obovate, firm in texture, 10–18 cm. long, 5–9 cm. wide, rounded, emarginate or subtruncate at the apex, narrowed or subtruncate at the base, dark green and glabrous above, densely white-lanate beneath, the midvein channeled above, prominent beneath, the lateral veins widely spreading, averaging 6 or 7 mm. apart, united close to the margin, the stout, somewhat pubescent petioles 1–2.5 cm. long; peduncle 3–11 cm. long, glabrous; cymes many-flowered, dense; pedicels 10 mm. long or less, glabrous or pubescent; calyx subtruncate, 2–3 mm. long; corolla-tube about 1.5 cm. long; corolla-lobes broadly elliptic-obovate, white, rounded, 1.5–2.5 cm. long, 1.2–2 cm. wide; follicles 8–10 cm. long, about 1 cm. thick, short-pointed.

Coastal rocks, vicinity of Baracoa, Oriente (*Underwood & Earle 1442*).

4. PLUMIERA CLUSIOIDES Griseb. Cat. Pl. Cub. 171. 1866

? *P. obtusa parvifolia* Griseb. Mem. Am. Acad. II. **8**: 519. 1862.

? *P. clusioides parvifolia* Maza, Anales Soc. Esp. Hist. Nat. **23**: 273. 1894.

Rocky hillsides and palm-barrens, Oriente; Camaguey; Santa Clara, Havana. Endemic.

Fruiting specimens collected by Dr. Shafer in the gorge of the

Rio Yamuri, Oriente (*7800*), tentatively referred to this species, have spatulate leaves 12 cm. long.

5. **Plumiera nipensis** sp. nov.

A slender tree, up to about 6 m. in height. Leaves narrowly oblong, 9–12 cm. long, 1.5–2.3 cm. wide, obtuse at the apex, narrowed at the base, glabrous on both sides, shining above, dull beneath, the midvein channeled above, prominent beneath, the lateral venation widely spreading, impressed, but distinct, above, the rather slender petioles 1 cm. long or less; peduncle stout, 6 cm. long; follicles 13–15 cm. long, about 2 cm. thick, acutish; seeds 10 mm. long, 6–7 mm. wide, the wing about 15 mm. long, 8–9 mm. wide.

Rocky thicket, between Piedra Gorda and Woodfred, Sierra Nipe, Oriente, at 500 m. alt. (*Shafer 3089*). Perhaps the same as *P. obtusa laevis* Griseb. (Mem. Am. Acad. II. **8**: 519) from Monte Verde, Oriente.

6. PLUMIERA EMARGINATA Griseb. Cat. Pl. Cub. 171. 1866

Rocky cliffs and hillsides, Matanzas; Pinar del Rio; Isle of Pines. Endemic.

7. PLUMIERA OBTUSA L. Sp. Pl. 210. 1753

Coastal hills, keys and thickets, Oriente; Camaguey; Santa Clara:—Bahamas; Hispaniola; Mona. Attributed to Jamaica, but some specimens which have been so referred represent a distinct species.*

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* **Plumiera confusa** sp. nov.

A tree, up to 6 m. high, little branched, glabrous throughout. Leaves narrowly elliptic or oblong, shining, 1–3 dm. long, 7 cm. wide or less, obtuse, emarginate or acute at the apex, narrowed at the base, the midvein channeled above, prominent beneath, the lateral venation widely spreading, the stout petioles 4–8 cm. long; peduncles stout, 7–15 cm. long; cymes large, many-flowered; pedicels rather stout, thickened upward, 9–12 mm. long; calyx nearly truncate, about 3 mm. long; corolla white with a pale yellow eye, its tube 12–15 mm. long, its lobes broadly oblong, rounded, 2.5–3 cm. long, about 1 cm. wide; follicles 8–12 cm. long, 10–12 mm. thick.

Rocky situations, southern side of Jamaica. Type collected on Great Goat Island (*Harris 9309*);

The species more resembles *P. emarginata* than *P. obtusa*. I am unable to determine, from the material available at this time, whether *P. obtusa* occurs on Jamaica or not. Other specimens referable to *P. confusa* are: Healthshire Hills near Salt Island (*Britton 3061*); base of Healthshire Hills near Salt Ponds (*Britton 3036*); Great Goat Island (*Harris 10168; Britton 1874*).

The *Plumiera* of Pedro Bluff, a locality about thirty miles west of Great Goat Island, but still within the xerophytic region, may be *P. obtusa*, but the specimen

8. **Plumiera venosa** sp. nov.

A tree up to 6 m. high, glabrous throughout. Leaves oblong-oblanceolate to narrowly obovate, 7–15 cm. long, 3 cm. wide or less, obtuse or emarginate at the apex, narrowed or cuneate at the base, the midvein impressed above, prominent beneath, the lateral veins numerous, widely spreading, united near the margin, 2–3 mm. apart, prominent beneath; petioles slender, 2–3 cm. long; cymes several–many-flowered; peduncles 6–10 cm. long; pedicels 8–15 mm. long, upwardly somewhat thickened; calyx about 3 mm. long, its teeth very broad and short; corolla-tube about 1.5 cm. long; corolla-lobes narrowly oblong-oblanceolate, 2–2.7 cm. long; follicles 10–15 cm. long, about 12 mm. thick; seed nearly 1 cm. long, its wing about 1.5 cm. long.

Coastal cliffs and hillsides near the coast, southern Oriente. Type collected in the basin of Rio Guama, Sevilla Estate near Santiago (*Taylor 93*).

Shoots from cut stumps bear nearly linear leaves up to 2 dm. long, 10–15 mm. wide, as seen by me in a coastal thicket near the mouth of Santiago Harbor (*Britton & Cowell 12632*).

9. **Plumiera trinitensis** sp. nov.

A tree 5 m. high. Leaves oblong to oblong-oblanceolate, 11 cm. long or less, 1.5–3.5 cm. wide, obtuse or emarginate at the apex, gradually narrowed to the base, glabrous above, pubescent on the veins beneath, the midvein broad, channeled above, prominent beneath, the lateral veins rather widely spreading, 2–4 mm. apart, united near the revolute margins; petioles 1.5–2.5 cm. long; follicle slightly curved, pointed, 18 cm. long, about 1.5 cm. thick.

Dry hillside, La Vigia, Trinidad, Santa Clara (*Britton & Wilson 5514*). Similar to *P. jamaicensis* Britton, which is a glabrous species up to 10 m. high, with broader leaves.

(*Harris 9996*) is not complete. In 1895, E. Campbell collected a *Plumiera* at Constant Spring (*5973*), which may be *P. obtusa*.

Growing with *P. confusa* on Great Goat Island there is a *Plumiera* which has leaves over 3 dm. long, narrowly oblong to linear-oblong, some of them not more than 3 cm. wide, and all long-acuminate at the apex (*Britton 1870*). It was not in flower at the time of my visit, March 4, 1908, but I obtained its fruit, which is much like that of *P. confusa*, and its leaf-venation resembles that of *P. confusa* also; it may be that *P. confusa* is sufficiently heterophyllous to have these narrow, elongated, long-pointed leaves.

42. THE GENUS GUETTARDA L. IN CUBA

A. Leaves minute, nearly sessile, 6 mm. long or less. 1. *G. Echinodendron.*

B. Leaves larger, 1.5 cm. long or more.

a. Leaves spinulose-tipped.

Leaves ovate to elliptic, strongly reticulate-veined beneath. 2. *G. Coxiana.*

Leaves oblong, scarcely reticulate-veined beneath. 3. *G. cueroensis.*

b. Leaves not spinulose-tipped.

* Leaves small, 3.5 cm. long or less; flowers axillary, mostly solitary.

Leaves densely silvery-silky beneath. 4. *G. rigida.*

Leaves glabrous or somewhat pubescent beneath.

Flowers sessile or nearly so; leaves ovate or oblong.

Venation inconspicuous on upper leaf-surfaces.

Corolla nearly 2 cm. long; calyx spathaceous. 5. *G. camagueyensis.*

Corolla 1–1.5 cm. long.

Calyx spathaceous; corolla-tube little longer than the limb. 6. *G. clarensis.*

Calyx truncate or oblique; corolla-tube 3–4 times as long as the limb. 7. *G. undulata.*

Venation prominent on upper leaf-surfaces. 8. *G. xanthocarpa.*

Peduncles nearly as long as the fruits; leaves obovate. 9. *G. sciaphila.*

** Leaves larger, 3.5–15 cm. long.

† Inflorescence capitate or clustered or flowers solitary at the ends of twigs, or some flowers also peduncled in the upper axils.

Inflorescence capitate-clustered.

Leaves densely pubescent or puberulent beneath.

Leaves densely puberulent beneath. 10. *G. densiflora.*

Leaves villous beneath, at least on the veins.

Fruit 2–3 cm. in diameter. 11. *G. macrocarpa.*

Fruit 6–15 mm. in diameter.

Fruit 10–15 mm. in diameter, densely puberulent; leaves densely villous beneath. 12. *G. ferruginea.*

Fruit about 6 mm. in diameter, villous; leaves villous on the veins beneath. 13. *G. lanuginosa.*

Leaves pubescent only on the veins beneath. 14. *G. crassipes.*

Flowers solitary or sometimes 2. 15. *G. zygophlebia.*

†† Inflorescence axillary, peduncled.

‡ Inflorescence 1–several-flowered.

Leaves cordate at the base; corolla 3–4 cm. long. 16. *G. calyptrata.*
Leaves not cordate; corolla much smaller.
Leaves glabrous on both sides, coriaceous.
Peduncles short, 3–15 mm. long, 1–2-flowered. 17. *G. monocarpa.*
Peduncles long, 3–8 cm. long, few–several-flowered. 18. *G. Valenzuelana.*
Leaves thin, pubescent beneath, at least on the veins.
Leaves appressed-silky beneath, long-acuminate at the apex. 19. *G. calcicola.*
Pubescence not silky; leaves obtuse to acute or short-acuminate.
Fruit oblong. 20. *G. Lindeniana.*
Fruit subglobose.
Leaves prominently reticulate-veined beneath.
Leaves setulose above. 21. *G. brevinodis.*
Leaves not setulose above. 22. *G. inaequipes.*
Leaves not prominently reticulate-veined beneath. 23. *G. elliptica.*
‡‡ Inflorescence several–many-flowered.
Leaves thick, scabrous above. 24. *G. scabra.*
Leaves thin, smooth above. 25. *G. Combsii.*
C. Species known to me only from the description. 26. *G. retusa.*

1. GUETTARDA ECHINODENDRON C. Wright; Sauvalle, Anales Acad. Habana **6**: 124. 1869

Stenostomum microphyllum Griseb. Cat. Pl. Cub. 133. 1866. Not *Guettarda microphylla* Bartl.

TYPE LOCALITY: Near San Marcos, western Cuba.

DISTRIBUTION: Known only from the type locality.

2. **Guettarda Coxiana** sp. nov.

A shrub, 2.5 m. high, with short, slender, densely pubescent twigs, the leaf-scars long-persistent. Stipules ovate, acuminate, 2–3 mm. long; leaves ovate or ovate-elliptic, 2 cm. long or less, coriaceous, rigid, the apex acute and spinulose-tipped, the base obtuse, the upper surface smooth, with indistinct venation, the under surface very prominently reticulate-veined and densely pubescent, the stout pubescent petiole 1–2 mm. long; peduncles axillary, 1-flowered or 2-flowered, pubescent, 2.5–3 mm. long; bractlets subulate, 1 mm. long; calyx obconic, truncate, densely puberulent, 2 mm. long; corolla yellowish, densely puberulent,

about 3 mm. long; young fruit narrowly obovoid, puberulent, faintly ribbed, 4 mm. long, the persistent calyx-limb about 1.5 mm. long.

Rocky coastal hill, Daiquiri, Oriente (*Britton & Cowell 12685*). Named in memory of the late Jennings S. Cox, who, as manager of the Spanish American Iron Company, greatly facilitated scientific investigation in eastern Cuba.

3. **Guettarda cueroensis** sp. nov.

A tree 5 m. high, with slender branches, the young twigs appressed-pubescent. Stipules ovate, acute, pubescent, 2–3 mm. long; leaves clustered at the ends of short spurs, oblong to oblong-lanceolate, 3 cm. long or less, 6–12 mm. wide, coriaceous, acute and spinulose-tipped at the apex, obtuse or subtruncate at the base, loosely reticulate-veined on both sides, glabrous and shining above, puberulent beneath, the finely pubescent petiole 1.5–2 mm. long; flowers solitary in the axils; peduncles pubescent, stout, 2 mm. long or less; calyx subspathaceous, densely pubescent, about 3 mm. long; corolla whitish, densely pubescent, about 8 mm. long, the slender tube about 3 times as long as the limb; fruit subglobose, or globose-obovoid, densely puberulent, 8–10 mm. in diameter.

Hill, 150 m. alt., El Cuero, Oriente (*Britton & Cowell 12733*).

4. GUETTARDA RIGIDA A. Rich. in Sagra, Hist. Cub. **11**: 20. 1850

G. holocarpa Wright; Sauvalle, Anales Acad. Habana **6**: 123. 1869.

TYPE LOCALITY: Cuba.

DISTRIBUTION: Thickets and hillsides, near Regla and Guanabacoa, Havana. Endemic.

I have not seen an authentic specimen of *G. rigida*, and am referring *G. holocarpa* to it from the description. It is the only small-leaved species with silky pubescence on the under side of the leaf known to me from Cuba.

5. **Guettarda camagueyensis** sp. nov.

A shrub, 1 m. high, with terete, widely spreading branches, the young twigs brownish-pubescent with appressed hairs. Stipules pubescent, ovate, sharply acute, 3–4 mm. long; leaves ovate, rigid, coriaceous, 1.5–2.5 cm. long, 10–18 mm. wide, rounded and obtuse at the apex, cordate or subcordate at the base, ciliate, at

least when young, smooth, glabrous and inconspicuously veined above, densely reticulate-veined and pubescent beneath the stout petioles about 1 mm. long; flowers solitary and nearly sessile in the axils; calyx spathaceous, appressed-pubescent, 5–6 mm. long, its lobes acute; corolla white, appressed-pubescent with long hairs, about 1.7 cm. long, the limb about one-third as long as the slender tube; fruit nearly sessile, globose, densely brownish-puberulent, about 12 mm. in diameter.

Palm-barren between Camaguey and Santayana (*Britton 2409*, type); Corojo, Camaguey (*Brother Leon 3725*).

6. **Guettarda clarensis** sp. nov.

A shrub with terete branches, the young twigs densely pubescent with long brown, somewhat spreading hairs. Stipules ovate, acute, pubescent, 5 mm. long, deciduous; leaves ovate-oblong, 2.5 cm. long or less, 8–14 mm. wide, obtuse at the apex, subcordate at the base, loosely pubescent with spreading brown hairs and inconspicuously veined above, prominently and densely reticulate-veined and pubescent beneath, the elevated midrib bearing long brown hairs; petioles stout, villous, scarcely 1 mm. long; flowers sessile and solitary in the axils; calyx spathaceous, appressed-pubescent, about 5 mm. long, its broad lobes acutish; corolla about 1 cm. long, its stout tube densely clothed with long appressed, white hairs.

Palm-barren, city of Santa Clara (*Britton & Wilson 6176*).

7. GUETTARDA UNDULATA Griseb. Cat. Pl. Cub. 131. 1866

TYPE LOCALITY: Rocky situations near Matanzas.

DISTRIBUTION: Known only from the type locality [near Punta Brava].

8. **Guettarda xanthocarpa** sp. nov.

A much-branched shrub, 1.5 m. high, the short, spur-like twigs terete, leaf-bearing at the ends. Stipules ovate, puberulent, about 1.5 mm. long; leaves oblong to oblong-lanceolate or elliptic, 2 cm. long or less, 6–12 mm. wide, coriaceous, glabrous or nearly so, acute or obtuse at the apex, subcordate at base, loosely and rather prominently reticulate-veined above, densely and finely reticulate-veined beneath, the puberulent, stout petiole 1–1.5 mm. long; fruit subglobose, yellow, densely puberulent, 6–8 mm. in diameter.

Coastal cliffs, near El Morro, Santiago Bay, Oriente (*Britton & Cowell 12538*, type); eastern Cuba (*Wright 2705*).

Grisebach referred Wright's *2705* to *G. undulata* Griseb.,

from which it differs in leaf-venation and pubescence; it also differs from our *12538* by shorter, broader and obtuse leaves, but is otherwise similar; when flowers are obtained it may, perhaps, be shown that they are distinct species.

9. GUETTARDA SCIAPHILA Urban, Symb. Ant. **7**: 409. 1912

TYPE LOCALITY: Near the base of Loma Mensura, Oriente.

DISTRIBUTION: Known only from the type locality.

10. GUETTARDA DENSIFLORA Urban, Symb. Ant. **7**: 407. 1912

TYPE LOCALITY: Pine-lands near Paso Estancia, Oriente.

DISTRIBUTION: Pine-lands, hillsides and savannas, northern Oriente.

Dr. Shafer's *3794*, collected on Loma Mensura, shows its fruit to be subglobose, puberulent, and about 12 mm. in diameter.

11. GUETTARDA MACROCARPA Griseb. Mem. Am. Acad. II. **8**: 507. 1862

TYPE LOCALITY: Near Monte Verde, Oriente.

DISTRIBUTION: Known only from the type locality.

12. GUETTARDA FERRUGINEA Griseb. Cat. Pl. Cub. 131. 1866

G. calyptrata ferruginea C. Wright; Sauvalle, Anales Acad. Habana **6**: 123. 1869.

TYPE LOCALITY: Pine-lands near Mayari, western Cuba.

DISTRIBUTION: Type locality, and in the mountains of northern Oriente. Endemic.

13. GUETTARDA LANUGINOSA Urban & Britton; Urban, Symb. Ant. **7**: 407. 1912

TYPE LOCALITY: Cayo Romano, Camaguey.

DISTRIBUTION: Known only from the type locality.

14. **Guettarda crassipes** sp. nov.

A shrub 1–1.6 m. high, with stout twigs, the young ones densely appressed-pubescent. Stipules ovate, densely pubescent, about 7 mm. long, deciduous; leaves ovate to ovate-elliptic, 6–9 cm. long, 4–7 cm. wide, coriaceous, shining, glabrous and with impressed primary venation above, dull, with elevated primary venation, and very finely reticulate-veined beneath, sparingly

pubescent on the stronger veins, obtuse at the apex, cordate at the base, the stout, brown petioles 1 cm. long, densely appressed-pubescent; inflorescence terminal, subcapitate, about 9-flowered; bracts lanceolate, densely pubescent; flowers nearly sessile; calyx subtruncate, densely appressed-pubescent, 4 mm. long; corolla white, densely villous-pubescent, in bud about 15 mm. long.

Between Rio Yamaniguey and Camp Toa, northern Oriente, at 400 m. alt. (*Shafer 4193*).

15. GUETTARDA ZYGOPHLEBIA C. Wright; Sauvalle, Anales Acad. Habana **6**: 124. 1869

TYPE LOCALITY: Arroyo in the Cafetal Potosi, Monte Toro, Oriente.

DISTRIBUTION: Known only from the type locality.

16. GUETTARDA CALYPTRATA A. Rich. in Sagra, Hist. Cub. **11**: 21. 1850

TYPE LOCALITY: Near Canasi, Cuba.

DISTRIBUTION: Woods and thickets, Santa Clara, Matanzas, Havana, Pinar del Rio, Isle of Pines. Endemic.

ILLUSTRATION: A. Rich. in Sagra, *loc. cit.*, *pl. 46*.

17. GUETTARDA MONOCARPA Urban, Symb. Ant. **7**: 410. 1912

TYPE LOCALITY: Pine-lands, Sierra Nipe near Woodfred, northern Oriente.

DISTRIBUTION: Woods and thickets, mountains of northern Oriente. Endemic.

18. GUETTARDA VALENZUELANA A Rich. in Sagra, Hist. Cub. **11**: 20. 1850

Guettarda bracteata Griseb. Mem. Am. Acad. II. **8**: 506. 1862.

TYPE LOCALITY: Vuelta de Abajo (Pinar del Rio), Cuba.

DISTRIBUTION: Mountains of Pinar del Rio and of northern Oriente. Endemic.

I am referring Grisebach's species to that of A. Richard with some hesitation, as did Grisebach himself (Cat. Pl. Cub. 131. 1866), but specimens from Bahia Honda, Pinar del Rio (*P. Wilson 9441*) do not appear different from several from Oriente, including a co-type (*Wright 261*) from Monte Verde.

19. **Guettarda calcicola** sp. nov.

A tree up to 5 m. high, with slender branches, the young twigs densely appressed-pubescent. Stipules ovate, appressed-pubescent with long hairs, about 4 mm. long; leaves oblong-elliptic to ovate-lanceolate, membranous, 4–8 cm. long, 3.5 cm. long or less, acuminate at the apex, acute or acuminate at the base, shining, prominently pinnately veined, with slender, ascending veins, loosely reticulate-veined and sparingly appressed-pubescent on the veins above, appressed-silky beneath, the slender petioles 3–8 mm. long; inflorescence axillary; peduncles slender, as long as the leaves or shorter, several-flowered; calyx subtruncate, appressed-pubescent, about 1.5 mm. long; young fruit oblong to oblong-obovoid, densely finely appressed-pubescent, about 5 mm. long, crowned by the calyx-limb.

Limestone rocks, near Sumidero, Pinar del Rio (*Shafer 13454, type*).

In leaf-venation and pubescence similar to the Haitian *G. multinervis* Urban, which has globose fruit.

20. GUETTARDA LINDENIANA A. Rich. in Sagra, Hist. Cub. 11: 20. 1850

TYPE LOCALITY: Near Santiago, Cuba.

DISTRIBUTION: Lower and middle elevations, Oriente. Endemic.

21. GUETTARDA BREVINODIS Urban, Symb. Ant. 7: 404. 1912

TYPE LOCALITY: Cuba.

DISTRIBUTION: Rocky limestone hills, Pinar del Rio. Endemic.

This does not appear to me to be certainly distinct from the following.

22. GUETTARDA INAEQUIPES Urban, Symb. Ant. 7: 405. 1912

TYPE LOCALITY: Cuba.

DISTRIBUTION: Known only from the type specimens (*Wright 2702*, in part), their exact station not recorded. This and the preceding species were referred by Grisebach to *G. membranacea* Sw., of Hispaniola, and by Wright to *G. Lindeniana* A. Rich.

23. GUETTARDA ELLIPTICA Sw. Prodr. 59. 1788

G. reticulata Griseb. Mem. Am. Acad. II. 8: 506. 1862.

TYPE LOCALITY: Jamaica.

DISTRIBUTION: Thickets at low elevations near the coasts, Oriente; Camaguey; Santa Clara; Matanzas; Havana:—Florida; Bahamas; Jamaica; Hispaniola; Porto Rico; Mexico. Referred by A. Richard and by Grisebach to *G. odorata* Lam.

ILLUSTRATION: Sargent, Sylva N. A. *pl. 229;* Man. Trees *f. 617;* Britton & Shafer, N. A. Trees *f. 768.*

24. GUETTARDA SCABRA (L.) Lam. Tabl. Encycl. **2**: 218. 1793

Matthiola scabra L. Sp. Pl. 1192. 1753.
G. rugosa Sw. Prodr. 59. 1788.
G. havanensis DC. Prodr. **4**: 455. 1830.
G. ambigua A. Rich. in Sagra, Hist. Cub. **11**: 20. 1850. Not DC.

TYPE LOCALITY: "In America."

DISTRIBUTION: Thickets and woodlands at lower elevations, Oriente; Camaguey; Santa Clara; Matanzas:—Florida; Bahamas; Hispaniola to Tortola, Anguilla, Grenada and Margarita; Central America; recorded from Jamaica.

25. GUETTARDA COMBSII Urban, Symb. Ant. **6**: 48. 1909

TYPE LOCALITY: Near Cieneguita, Santa Clara, Cuba.

DISTRIBUTION: Savannas and woodlands at lower elevations, Santa Clara; Matanzas; Pinar del Rio. Endemic.

Referred by Grisebach to *G. longiflora* Griseb. of Jamaica.

26. GUETTARDA RETUSA C. Wright; Sauvalle, Anales Acad. Habana **6**: 124. 1869

TYPE LOCALITY: La Loma Pelada, Palacios, Pinar del Rio.

DISTRIBUTION: Known only from the type locality and to me only from the description, which is insufficient to enable me to group the species.

43. UNDESCRIBED WEST INDIAN SPECIES

Coccolobis rumicifolia sp. nov.

A shrub, 3 m. high, with slender branches. Leaves elliptic-lanceolate, membranous, glabrous, 15 cm. long or less, 3–7 cm. wide, acutish to acuminate at the apex, obtuse, subcordate or acute at the base, the midvein nearly flat above, prominent beneath, the primary lateral veins about 12 on each side of the mid-

vein, faint above, rather prominent beneath, the ultimate venation coarsely reticulated, the petioles about 1 cm. long, the ochreae 4–5 mm. long; racemes slender, simple, minutely puberulent, 6–12 cm. long; ochreolae subtruncate, 0.5 mm. long, about as long as the bracts; flowering pedicels spreading, 1–3 at each ochreola, 1 mm. long; perianth about 1.5 mm. long, its lobes obtuse.

Wooded hillside, Tea Gully near Newmarket, Jamaica (*Britton 1592*).

Portulaca caulerpoides Britton & Wilson, sp. nov.

Perennial, prostrate, forming tufts 8–12 cm. in diameter; stems slender, branched, hairy in the axils. Leaves obovoid, 3–5 mm. long, 2–3 mm. broad, not at all flattened, rounded at the apex, narrowed at the base, subsessile, glabrous, shining, with labyrinthine or tortuous mottling; flowers terminal, solitary, sessile; sepals oval; petals pale yellowish-white, broadly obovate, 2.5–3 mm. long, 2–2.5 mm. broad, notched at the apex; seeds reniform, black, 0.5 mm. broad, rugulose.

Limestone rocks, Cayo Muertos, Porto Rico (*Britton, Cowell & Brown 4990*).

The aspect of this species is similar to that of the green alga *Caulerpa clavifera*, which occurs in the adjacent sea.

Chamaecrista jamaicensis sp. nov.

A shrub up to 1.3 m. high, the slender branches appressed-pubescent. Stipules lance-subulate, acuminate, striate, 2–4 mm. long; petioles 6 mm. long or less, bearing a nearly cylindric gland 1–1.5 mm. long near the lowest pair of leaflets; rachis pubescent; leaflets 4–8 pairs, dull, coriaceous, sessile, glabrous, oblong, or the two upper ones oblong-obovate, 13–22 mm. long, 8 mm. wide or less, prominently many-veined, obtuse and mucronate at the apex, rounded at the base, inequilateral; peduncles bracted, pubescent, 1-flowered, shorter than the leaves; bracts lanceolate, long-acuminate, striate, about 4 mm. long; sepals lanceolate, acuminate, about 1 cm. long, broadly scarious-margined, pubescent on the back with scattered, appressed hairs; petals obovate, short-clawed, somewhat unequal, about as long as the sepals; longer anthers 9 mm. long; pod obliquely linear, 3–4 cm. long, about 6 mm. wide, pubescent with scattered hairs.

Dry soil near the southern coast of Jamaica. Type from the south slope of Long Mountain (*Britton 811*).

Referred by Grisebach to *Cassia polyadena* DC., originally from

Guadaloupe; I studied the type specimen of *C. polyadena* in the Candollean herbarium at Geneva a number of years ago; it is, in my opinion, specifically distinct from the Jamaica plant.

Rhamnidium ellipticum Britton & Wilson, sp. nov.

A glabrous tree 8 m. high; leaves narrowly to broadly elliptic, occasionally somewhat obovate, 3.5–6.5 cm. long, 1.3–3 cm. broad, obtuse or rounded and usually emarginate at the apex, rounded or obtuse at the base, coriaceous, entire, above lustrous, the midvein and primary veins indistinct, pale beneath, the midvein and primary veins prominent; margin revolute; petioles 5–6 mm. long, channeled; peduncles 1.5–3 cm. long, few-flowered; pedicels 5 mm. long; calyx-lobes triangular-ovate; fruit obovoid, 1 cm. long, 6 mm. broad, glabrous.

Rocky hillside along trail, Rio Yamaniguey to Camp Toa, Oriente, Cuba (*Shafer 4005*).

Rhamnidium Shaferi Britton & Wilson, sp. nov.

A glabrous tree 3 m. high; leaves oblong-oval to oval, occasionally ovate-oval, 5–6.5 cm. long, 3–3.8 cm. broad, rounded and emarginate at the apex, cordate at the base, lustrous above and indistinctly reticulate-veined, beneath paler, the midvein and primary veins prominent; petioles 9–15 mm. long, narrowly grooved; peduncles 7–10 mm. long, few-flowered; pedicels 3 mm. long; buds ovoid.

Camp La Gloria, south of Sierra Moa, Oriente, Cuba (*Shafer 8192*).

Rhamnidium (?) **cubensis** Britton & Wilson, sp. nov.

A shrub 3 m. tall, with grayish bark and puberulent twigs. Leaves oblong-elliptic to narrowly oblong-ovate or oblong-obovate, 2–4 cm. long, 1–1.6 cm. broad, rounded and emarginate at the apex, obtuse at the base, entire, lustrous above, the primary veins prominent, reticulate-veined and paler beneath, rigid, glabrous, black-dotted, the petioles 2–3.5 mm. long, puberulent above and shallowly channeled; flower-clusters lateral, axillary; sepals triangular-ovate, acuminate, glabrous, with a conspicuous row of black glands paralleling the margin; petals hooded, broadly triangular-obovate; filaments subulate, glabrous; anthers ovate; ovary ovoid, glabrous; ovules one in each cavity.

Rocky coastal hills, vicinity of El Morro, Santiago Bay, Oriente, Cuba (*Britton & Cowell 12554*).

Nashia cayensis sp. nov.

A densely branched, aromatic shrub, the slender pendent branches finely rough-pubescent. Leaves ovate to elliptic, 15 mm. long or less, 5–9 mm. wide, obtuse or acutish at the apex, mostly rounded at the base, scabrous above, pubescent and glandular beneath, strongly few-veined with the venation impressed above, prominent beneath, the petioles about 1 mm. long; heads solitary in the axils, nearly sessile, globular and about 5 mm. in diameter when in flower, oblong-cylindric and 10–15 mm. long in fruit, densely many-flowered; bracts broadly ovate to obovate, pubescent and ciliate, about 3 mm. long; calyx of 2 narrowly spatulate sepals nearly as long as the corolla; corolla greenish, scarcely longer than the bracts, the somewhat irregular limb about as long as the campanulate tube; filaments very short; fruit orange-red, about 2 mm. in diameter.

Near Pueblo Romano, Cayo Romano, Camaguey, Cuba (*Shafer 2450*). Similar to *Lippia myrtifolia* Griseb., and clearly congeneric with the generic type, *N. inaguensis* Millsp.

Exostema stenophyllum sp. nov.

A shrub, up to 2 m. high, glabrous throughout, the slender twigs rather densely leafy. Leaves linear to linear-oblanceolate, 6 cm. long or less, 4–6 mm. wide, subcoriaceous, obtusish or acute at the apex, narrowed to the sessile base, revolute-margined, the midvein impressed above, prominent beneath, the lateral venation wholly obscure; stipules semicircular or short-ovate, obtuse, mucronulate, about 2 mm. long; flowers terminal, solitary; peduncle 1–1.5 cm. long; calyx narrowly campanulate, 8–10 mm. long, its ovate-lanceolate acute teeth about one-third as long as the tube; corolla white; corolla-tube about 14 cm. long, 1.5 mm. thick; lobes of the corolla-limb linear, 2–3 cm. long; anthers narrowly linear, about 18 mm. long and about as long as the filaments; capsule oblong, 1.5–2.2 cm. long, about 8 mm. in diameter.

Among rocks at the water's edge, Rio Guayabo above the falls, 450–550 m. alt., Oriente (*Shafer 3623*).

The effect of the host on the morphology of certain species of Gymnosporangium

B. O. Dodge

(WITH PLATES 28 AND 29)

The large number of rather closely related species of *Gymnosporangium* which have been described as infecting such host plants as the red cedar, *Chamaecyparis*, the juniper, etc., on the one hand, and the hawthorns, apples, shad-bush, etc., on the other, raises the question as to the relation of the particular host to the specific differences in the parasite.

It is commonly accepted (**17**, **18**) that certain species of *Gymnosporangium* gain entrance into the tissues of the coniferous host through leaf infection. In the case of *G. macropus* on the red cedar, strictly foliicolous galls are often quite numerous. To what extent species of *Gymnosporangium* are perennial and whether in such cases sori may develop on the leaves as well as on the branches or trunk does not appear to have been definitely determined in many species. Reed and Crabill (**18**) claim that the mycelium of *G. macropus* never penetrates beyond the base of the leaf into the twig. The leaf forms which Farlow (**3**) referred to *G. clavipes* were later found to belong to *G. nidus-avis*, now believed to develop on all parts of the red cedar. When the trunk or branches are attacked the bark is split open or deeply furrowed. The same species may produce the witch's-broom or bird's-nest malformations, and isolated sori may even be found at the base of the leaves or possibly on the leaves themselves. Farlow and Thaxter, in their later publications (**4**, **20–22**), cleared up the points relating to the identity of *G. nidus-avis*, so that one is not left in doubt as to their conceptions of the variations and limitations of this "multiform species."

I am studying a somewhat similar case in connection with *G. biseptatum*, which is perennial in the branches or trunk of *Chamaecyparis*. The teleutospores are commonly three- or four-celled,

but there also occur numerous two-celled spores mixed in with the others. Certain specimens confined to the leaves were distributed by Seymour and Earle as *G. biseptatum* var. *foliicolum* (Econ. Fungi *244*). Ellis also found this variety at Newfield, New Jersey (N. Am. F. *1479*). Farlow's comments clearly set forth the essential facts in regard to the two forms, and I quote the following paragraph from his early work on the *Gymnosporangia* of the United States (**3**): "The spores of the present species (*G. biseptatum*) are characterized by the great variability in the number of cells of which they are composed. The most usual number is three or four, two are rather common and occasionally there are as many as six. . . . The spores of the present species when full grown are not easily mistaken for those of any other species, but the young tufts on the leaves often bear spores which are all, or nearly all, two-celled. I have received specimens from Mr. Ellis, with the fungus confined to the leaves, and it was difficult to say to what species to refer it. Large sets of specimens collected at Newton, however, show that while the young spots on the leaves may have principally two-celled spores, those on the smaller branches have about an equal proportion of two- and three-celled spores, and the still older branches have a large proportion of three-celled spores. In short, the variability is so great that without a large set of specimens, one would have difficulty in convincing himself that the extreme forms belonged to the same species." It should be noted that Farlow has apparently seen spores with more than two cells in the leaf sori. Thaxter (**20**) first showed the connection between *G. biseptatum* and *Roestelia Botryapites* on *Amelanchier*, but I do not find that he produced the infection by using spores from sori on the leaves.

Kern (**9**) describes this leaf form on *Chamaecyparis* as a new species under the name *G. fraternum*, on the basis of "its habit and morphological characters distinct from *G. biseptatum*."

Jackson (**8**) and Meineke (**12**) have found witch's-brooms on *Libocedrus*, supposed to be caused by *G. Blasdaleanum*, which has hitherto been thought to be strictly foliicolous (**9**, **10**). Jackson used spores from such specimens and found that the aecidia produced were the same as those derived from infections with spores from the leaf form. This species furnishes an example of

a most striking case of uniformity in the characters of the aecidial stage when developed on hosts of different genera. O'Gara (13) and Jackson (8) have been able to infect species in six different genera of the apple family with this rust. *Malus*, *Pyrus*, *Sorbus*, *Cydonia*, *Amelanchier* and *Crataegus* are susceptible. The constant uniformity of the aecidia on these different hosts, and their "conformity to type" of well authenticated specimens of this rust are their main reliance in assuming that they are working with *Gymnosporangium Blasdaleanum* on the *Libocedrus*.

On the other hand, Pammel (14) has given some data relative to the variations occurring in the aecidiospores and peridial cells when the aecidia of *G. macropus* are found on different host plants. The conditions under which his experiments were made are not given. He reports the infection of the wild crab and *Crataegus mollis* with *G. macropus*, and figures peridial cells and spores from aecidia on each of these hosts and on the common apple. There are noticeable differences in the size, form, and markings of these cells. He says: "In *Crataegus punctata* as well as *C. mollis* the peridial cells extend much longer beyond the surface of the leaf, and they are more finely lacerate. In *Pyrus Iowensis* the cups are shorter, darker brown, and the peridial cells do not cling together as in the *Crataegi*. In the cultivated apple the cups are smaller than [on] either of the other host plants. They project but slightly beyond the surface." It is a common practice, where the aecidial host is known to harbor several species of *Gymnosporangium*, to consider the peridial cells as the most satisfactory means of determining the species of rust, just as the markings on the ascospores of certain species of Discomycetes are thought to be good specific characters. It is well known that the cells at the apex of the peridium differ in length from those at the base, but the shape and markings have been assumed to be fairly constant.

Long (11) has also recently reported variations in *Puccinia Ellisiana* when grown on *Viola* and on *Pentstemon*. On the former host the aecidia are from one to four times as long, are greater in diameter, are deeper in color, have more peridial segments, and dehisce more tardily, while the aecidiospores are smaller than when the rust is grown on *Pentstemon*.

On April 29, 1911, I accompanied Dr. F. D. Kern (see Arthur, 1a) to Newfield, New Jersey, where we found a few specimens of *Gymnosporangium fraternum* in Holton's swamp, and also a quantity of *G. biseptatum*.* Visits made to Newfield and Lakehurst at various times since have afforded opportunity for further study of this stage of the rust.

During the first week in January the most careful inspection of several small marked cedars in the field failed to disclose any positive evidence of infection. Some of the leaves were slightly discolored or bore yellowish spots which contained what appeared to be a resinous substance but no spores. By the middle of March there were many leaves which were of a light waxy-yellow color throughout, and occasionally one could find, with the aid of a lens, lines of eruption from which teleutospores were just emerging. Sori were fully developed by the second week in April. The discoloration of the entire leaf seems to be confined to those which later bear very large sori. Where the sorus is comparatively small (PLATE 28, FIG. 1) the unoccupied parts of the leaf remain green. Infected leaves die off after the sori have disappeared through gelatinization. On June 1, 1914, it was not difficult to find sori, but they showed that in spite of the fact that it had been a very dry season, they had been previously swollen. Spores from these sori gave a low percentage of germination.

Greenhouse cultures, described later, indicate that the development of the sori can be hastened by at least two months. On the other hand, if small cedars are brought in from nature in the last week of March the "forcing process" is not especially effective. The same is true for *G. biseptatum*. Living branches with the fusiform swellings were obtained from Newfield March 21 and kept well watered and sprinkled. The first spores available for inoculation were ready April 13. At this time in nature their condition was much more satisfactory.

There is a great amount of variation in the shape, size, and the thickness of the walls of the spores of the foliicolous form. I have

* I shall use the name *G. biseptatum* to designate the perennial form now sometimes called *G. Botryapites*, and distinguish the foliicolous form on the same host by the name *G. fraternum*, since it will appear from what follows later that there must still be some uncertainty regarding the connections of the original "type," *Roestelia Botryapites*.

not found spores that had more than two cells. Kern (9) states that each cell has two pores near the septum. In the great majority of the spores the upper cell has a pore at the apex, and it is more frequently through this pore (PLATE 29, FIGS. 33–35, 37) that the germ tube appears. The pedicel possesses a characteristic feature noted by Farlow (3) in his discussion of "*G. clavipes*." The "collar," which remains attached to the lower end of the spore after the pedicel has swollen and has more or less disappeared through gelatinization, is apparently the upper portion of the stalk cell wall which becomes disorganized for the most part when moistened. The upper end still persists along with the protoplast which is seen as a long thread-like appendage. The stalk cell is originally cylindrical as described by Kern (9), but when moistened it frequently becomes carotiform (FIG. 26), resembling in this condition the pedicel of *G. clavipes*, though the thickening is much less noticeable. The two-celled spores of *G. biseptatum* resemble in every respect the spores of *G. fraternum* (FIGS. 31, 32).

On April 19, 1914, I found at Newfield a large quantity of *G. fraternum* on seedlings of *Chamaecyparis* a few inches high as well as on trees of all sizes. In a few cases the same branches bore both *G. biseptatum* and *G. fraternum*. The latter also occurred on small trees which were at the same time heavily infected with the witch's-brooms of *G. Ellisii*. At the place where *G. fraternum* was the most abundant there was a good growth of *Amelanchier* and *Aronia*. The leaf buds of the shrubs had not opened to any great extent, and there were no indications that the sori of the *Gymnosporangia* had reached sufficient maturity to have swollen and scattered sporidia during any rains that may have occurred previous to this date. The season was somewhat "late."

Infected seedling cedars were brought in and potted, and root sprouts of *Amelanchier*, *Aronia*, and *Pyrus* were also obtained from this locality and from the grounds of the New York Botanical Garden. It required five or ten days for the leaf buds to open sufficiently for these plants to be used for inoculation purposes; at the end of this time the sori on the cedars had also reached maturity.

Inoculations were made in the greenhouse, and the usual

methods, with slight modifications, were employed. Branches of cedar whose leaves bore sori were sprayed and hung over the trial host, which was then covered with a bell-jar for forty-eight hours. Two or three times during this interval the bell-jar was aired out and the plant sprayed. The sori of *G. fraternum* are so small that there is little danger of killing the alternate host by over infection. A larger number of plants can be more easily inoculated with a small supply of teleutospore material if the sori of germinating spores are shaken in a bottle with water so that the sporidia can be sprayed on the plants directly. The infection chamber mentioned by Fromme (**5**) has been employed with great advantage. This chamber is constructed by uniting five three-foot window sashes in the form of a box; the front sash is provided with hinges. It is large enough to hold fifteen or twenty plants in four- or six-inch pots, and plants up to two feet high can be inoculated easily under such conditions. The chamber can be aired out and the plants sprayed with little trouble. Another advantage to be gained by the use of this apparatus is the opportunity one has of providing similar conditions for several plants of different species which are being tried out. The old method of using leafy twigs instead of potted plants was also employed with more or less success.

The records contained in Table I* include only those cases in which the recently transplanted host lived fifteen days after inoculations were made. The Aronias from Newfield were badly spotted with small insect galls. The percentage of positive results was no doubt reduced on this account. The dates given in the last four columns refer to the time at which this particular stage was first observed although the fungus may have reached this stage some time previously and been overlooked. Where a date is replaced by a question mark (?) the aecidia were not seen until dehiscence was complete.

The plants used in these trials were chiefly species of *Aronia* and *Amelanchier*. As a large number of leaves on plants of these two genera first inoculated soon showed unmistakable signs of

* A preliminary report of this work has been published recently: Dodge, B. O. Relationship between *Roestelia transformans* and *R. Botryapites*. Torreya **15**: 133, 134. Je 1915.

infection, most of the succeeding experiments were carried out to check up the first results.

It is probable that no importance need be attached to the results obtained in numbers 200 and 221. Only one leaf on each apple seedling was infected, and this might have been due to the presence in the greenhouse of young red cedars bearing *G. macropus* and *G. globosum*. No aecidia developed on these leaves. Farlow (3) and Seymour (19) report *Roestelia transformans* on the cultivated apple. The pear and hawthorn were not infected, but as only one or two plants were tested these results are also inconclusive.

The table shows that about 50 per cent. of the Aronias were infected. Three different species were employed and all gave positive results. Aecidia matured on certain plants of *A. arbutifolia* and *A. nigra*, but the fungus on *A. atropurpurea* did not develop further than the formation of the large primary hypertrophies.

The interval between inoculation and the first appearance of the discoloration indicating infection varies from ten to fifteen days. The areas on the *Aronia* are not especially characteristic. They become raised or convexed and are frequently four or five millimeters in diameter (FIG. 3). After some days, ten to twenty, the parts attacked become sunken as the hypertrophies develop into bright green swellings directly beneath the pits. The galls sometimes seem to be three or four millimeters thick, but this apparent thickness is due in part to the pit in the upper surface of the leaf.

The horn-like processes of the galls (FIG. 4) begin to grow out a week or two later, after which the aecidia quickly develop and reach maturity within two months after inoculation. Frequently the development does not proceed further than the formation of the basal galls. The leaf remains in this condition for several weeks and new spermogonia are formed continually on the galls. Normally aecidia are matured whenever the cornute galls are developed.

FIGS. 7 and 8 show a case in which the growing point of a twig has been entirely transformed by the fungus. Eight weeks elasped between the taking of the photographs.

Occasionally infected leaves curl up soon after spermogonia

TABLE I

RECORD OF INFECTION EXPERIMENTS WITH THE FOLIICOLOUS FORM ON *Chamaecyparis* (*Gymnosporangium fraternum* KERN) IN 1914

No.	Trial host	Date inoc.	Spermogonia observed	Hypertrophy	Gall-horns	Aecidia appeared	Aecidia mature
200	*Malus Malus*	Apr. 25	June 15†				
201a	*Aronia nigra**	Apr. 23	May 5	May 19	July 28‡		
201b	*Aronia arbutifolia*	Apr. 23	May 5	May 19	June 5	June 18	June 21
202a	*Aronia nigra*	Apr. 25	May 6	June 10	July 1	July 12	July 24
202b	*Aronia arbutifolia*	Apr. 25	May 6	June 14	July 10	July 15	July 20
203a	*Amelanchier intermedia*	Apr. 25	May 6	May 25	June 14†		
203b	*Aronia arbutifolia*	Apr. 25	May 6	May 19	May 27	June 3	June 10
204	*Pyrus communis*	Apr. 25					
205	*Pyrus communis*	Apr. 25					
221	*Malus Malus*	Apr. 27	June 23§				
222	*Crataegus oxycantha*	Apr. 27					
242	*Aronia nigra*	May 6					
243	*Amelanchier Amelanchier*	May 6	May 19	May 28§			
245	*Amelanchier intermedia*	May 6	May 20§				
246	*Amelanchier intermedia*	May 6	May 17	June 4	Aug. 20	?	Sept. 10
249	*Amelanchier intermedia*	May 6	May 25§				
250	*Aronia arbutifolia*	May 6					
251	*Aronia arbutifolia*	May 6					
252	*Aronia arbutifolia*	May 6	May 16	May 24	June 12	June 25	July 5
253	*Aronia arbutifolia*	May 6	May 17	May 24	June 12	June 20	June 22
254	*Aronia arbutifolia*	May 6					
255	*Amelanchier intermedia*	May 6					
256	*Aronia arbutifolia*	May 6					
257	*Aronia arbutifolia*	May 6	May 19	June 15§			
258	*Aronia arbutifolia*	May 6					
259	*Aronia arbutifolia*	May 6					
265	*Aronia arbutifolia*	May 6					
267	*Aronia arbutifolia*	May 6	May 19§				
268	*Aronia arbutifolia*	May 6	May 16	May 26	June 6	June 17	June 20
269	*Aronia arbutifolia*	May 6					
270	*Aronia arbutifolia*	May 6	May 20	June 12§			
271	*Aronia atropurpurea*	May 11	May 26	June 12§			
272	*Aronia atropurpurea*	May 11					
273	*Aronia atropurpurea*	May 11					
274	*Aronia nigra*	May 11					
275	*Aronia nigra*	May 11					
277	*Aronia nigra*	May 11					
278	*Amelanchier intermedia*	May 11					
279	*Aronia nigra*	May 11	May 26	June 12†			
281	*Amelanchier intermedia*	May 11					
283	*Aronia nigra*	May 11	May 26	June 3	June 12	June 20	June 22
284	*Aronia nigra*	May 11					
344	*Aronia nigra*	June 3	June 21	July 20	Aug. 1	Aug. ?	Aug. 14

No.	Trial host	Date inoc.	Spermogonia observed	Hypertrophy	Gall-horns	Aecidia appeared	Aecidia mature
365	*Aronia arbutifolia* . . .	June 3	June 21§				
366	*Aronia arbutifolia* . . .	June 3					
368	*Aronia arbutifolia* . . .	June 3	June 23	July 10	July 14	July 18	July 23
372	*Aronia atropurpurea* .	June 3	June 12	June 28§			
373	*Aronia atropurpurea* .	June 3					
375	*Aronia nigra*	June 3	June 15	July 12	July 18	Aug. ?	Aug. 10

* Numbers 201*a*–205, and 279 were leafy twigs; all of the others were potted plants.

† Leaves died.

‡ Killed by "mealy bugs."

§ No further growth.

appear (FIG. 10), but the majority are not materially altered in shape (FIG. 12). FIG. 9 shows how the fungus may also attack young twigs below the growing point. A large number of aecidia develop on such malformations and on the fruit when it is attacked.

The aecidia are about one half millimeter in diameter and two to five millimeters in height, tapering gradually to a fine point (FIG. 15). Frequently those on *Aronia nigra* (FIG. 18) are taller. The dehiscence of the peridium is shown in FIGS. 15, 16, and 17. The cells at the apex do not split apart, and, as a result of the laceration of the portion of the peridium below the apex (FIG. 16) and the reaction of the mature cells to atmospheric changes, the top breaks away (FIG. 19), leaving the lower part of the cup fringed with a tangle of cells. The inner surface of a peridial cell is coarsely warted and most of them are pointed. Some have a notch at one end (FIG. 41), showing that they may overlap or dovetail. The only species known to possess such peridial cells is *Roestelia transformans*, the species that produces hypertrophies on *Aronia* such as I have described. The peridium is said (**9**, **16**) to dehisce at the apex first and gradually fall away. It is likely that collectors have failed to note the manner in which the tip end disappears. The galls are green until long after the aecidia are mature and not brownish as one finds them in dried specimens.

The twigs of *Amelanchier intermedia* used in number 203*a* were obtained at Newfield April 19 and inoculated April 25 with sporidia taken from swollen sori of *G. fraternum*. Spermogonia appeared on several leaves May 6. A potted root sprout of *A. intermedia* also from Newfield was used for number 249. At the

time of inoculation, May 6, the leaves were well out. A few infected areas appeared May 25 but no "subicular hypertrophies," projections, or aecidia subsequently developed. Similar root sprouts of *Amelanchier Amelanchier* and *A. intermedia* from the New York Botanical Garden were used in numbers 243 to 246, and 255. Spermogonia appeared on several in each case except in number 255, but the only one to mature aecidia was number 246. On June 4 hypertrophies were visible, which possessed characteristics quite different from those formed on the Aronias. At each point of infection on the *Amelanchier* leaves there were from two to six separate galls which grew to be about one or two millimeters high by July 22 as shown in FIG. 20. During the next three weeks the tubercles elongated slightly (FIGS. 21, 22). Aecidia reached maturity September 10. FIG. 43 shows an optical section of a peridial cell from the central part of an aecidium. The entire surface is smooth. The walls are not always of uniform thickness and the lumen does not appear to extend the full length of the cell. It is difficult to obtain such a view of an outer or inner surface of the cells of the peridia on *Aronia*. Those on the *Amelanchier* do not coil up in water to any great extent and, as they are merely "wavy" in outline, views of all sides may be obtained. Cultures made later show that two or three tubercular galls occasionally coalesce (FIG. 21) forming a solid mass of tissue from which the same number of aecidia develop. The basal gall subiculum on *Aronia* is often conspicuous from the first (FIG. 4). The horn-like parts are secondary. This is also in a measure true for the fungus on *Amelanchier*, where there is a very slight primary swelling, and one can not tell at first just how many ovoid outgrowths, and therefore how many aecidia, will be formed at any particular point of infection.

It is unnecessary to describe this rust as it appears on *Amelanchier* further at this point than to say that in the characters of the peridial cells and in the manner of dehiscence it corresponds very well in general with exsiccati specimens of *Roestelia Botryapites* on *Amelanchier* or to the original description of *R. Ellisii*, which has long been considered a synonym of *R. Botryapites*. In spite of the fact that no *Gymnosporangium biseptatum* was kept in the greenhouse the possibilities of contamination or mixture of

spores in the field at the time of collection were so great that, likewise, I should have attached no importance to these results were it not for the suggestions by Farlow (3) and others of a possible relationship between the ordinary perennial caulicolous form on *Chamaecyparis* and the "annual" leaf form on the same tree.

Comparing "*Gymnosporangium fraternum* on *Aronia*" and "*G. fraternum* on *Amelanchier*" we see two noteworthy differences: (1) the effect on the host; (2) the characters of the aecidia themselves. *Roestelia transformans* ("*Gymnosporangium fraternum* on *Aronia*") sometimes entirely transforms the terminal buds so that a large number of aecidia are produced on a massive gall; the same type of swelling may occur on young branches (FIGS. 7–9). The leaf may be more or less bent or deformed (FIG. 10). The aecidia arise in long horn-like projections of the host. In a majority of cases, however, in my cultures, as noted above, the *Aronia* leaves are not deformed and the primary or basal hypertrophy is not always prominent (FIG. 12).

Each aecidium of "*G. fraternum* on *Amelanchier*" arises from a gall which is more wart-like or ovoid. FIG. 20 shows such galls; the spot in the center of each indicates where the peridium will grow out. FIGS. 21–25 show further stages. The peridial cells are strikingly different in the two forms. They are very long in both cases. The cells from *Amelanchier* are irregularly bent or hypha-like and smooth on both surfaces (FIG. 43), while in those from *Aronia* the inner surface is invariably roughened with several series of warts (FIG. 41). The forms of the galls from which the aecidia arise are such as might be due to the reaction of different hosts to the stimulus of the same fungus.

The published infection experiments with *G. biseptatum* are very few. Certainly the possibility remains that *Aronia* can be infected with sporidia from the perennial caulicolous form. Arthur (1a) reports the infection of *Aronia* with *G. effusum*, and Kern (10) suggests that *G. effusum* and *Roestelia transformans* are possibly connected. Tubeuf, Saccardo, Sorauer, Pammel, and others have published more or less as a fact the connection between *G. Ellisii* and *Roestelia transformans*. I have repeated Fromme's (6) experiments with *G. Ellisii* and easily succeeded in infecting

Myrica caroliniana. Spermogonia appeared in seven days. Aecidia were ripe within four weeks. Four plants of *Comptonia* and ten of *Aronia* were inoculated at the same time in the same chamber, with negative results.

With the alternate hosts of *G. Ellisii* and *Roestelia transformans* known, only one phase of the question has been solved.

It is a common practice in establishing a connection between two phases of a heteroecious rust to rest content when the rust has been carried from one plant to the alternate host. The unsatisfactory state of our knowledge of several species of the genus *Gymnosporangium* is due in large part to the reluctance of investigators to undertake a piece of work involving such a length of time, and beset with difficulties such as they would be confronted with in any attempt to carry back the infection from the aecidial to the telial host. Plowright (17) and Arthur (1) appear to be, so far as I have learned, the only persons who report having carried such work through.

If the *Gymnosporangium* is a perennial then the number of years the telial host must be kept under strict control conditions before inoculations are made is no less serious a question than the time required to allow the rust to make its effects evident.

In case *Gymnosporangium fraternum* is confined to the leaves of the cedar and is annual, the converse infections should not be extremely difficult to get. If, on the other hand, the rust maintains itself in the wood tissues producing sori on new leaves each year, or after a number of years on the trunk or branches, the history of the successful experiment will be a long one. I have undertaken to carry on some work along this line, and in recording the results so far obtained I do not make any claim to have settled the questions involved.

INOCULATION OF *Chamaecyparis* WITH "*Roestelia transformans* ON *Aronia*"

Twenty-one cedars varying in height from four to twenty inches were brought from Newfield in April, 1914, and potted in the soil in which they had been growing. Some of them were heavily loaded with sori of *G. fraternum* at the time; others had only a few; eleven had none, so far as could be found.

Aecidia had begun to ripen on the Aronias (see Table I) about the middle of June and continued to shed spores for some time. The method of inoculation employed consisted in putting several cedars and Aronias bearing aecidia in the infection frame together and, in addition, the cedars were sprayed with aecidiospores. After two days in the frame, the plants were taken out and stacked together on the bench. This treatment was repeated two or three times with some of the cedars at intervals of about a week. No attempt was made to infect the cedars with spores from "*Gymnosporangium fraternum* on *Amelanchier*."

Certain of these cedars were "sunk" in the garden during the month of October and then put in the cold frame; others were left in the greenhouse until December or January and then put in the cold frame; those remaining were kept in the greenhouse all winter.

Beginning about the first week in December the cedars were removed from the cold frame one by one until all had been brought in by March. A very careful inspection of the plants as they were taken from the frame showed that no sori had developed. The results may be summarized under the five groups into which the plants may be divided according to their previous treatment or condition.

TABLE II

INOCULATION OF *Chamaecyparis thyoides* WITH *Roestelia transformans* ("*Gymnosporangium fraternum* ON *Aronia*") IN 1914

Plants free from sori in spring of 1914						Plants having sori in spring, 1914			
Inoculated June, July			Control, not inococulated			Inoc. June, July			Control†
No.	Result	Date	No.	Result	Date	No.	Result	Date	
		(1915)						(1915)	
432	+	Mr. 24	345	0		419	+	Jan. 22	
437	+	Mr. 26	346*	0		347	+	Feb. 7	
400	+	Mr. 29	433	0		404	+	Feb. 19	
445	+	Apr. 22	436	0		421	+	Mr. 5	
406	−		424a	0		435	+	Mr. 29	
409	−					348	+	Mr. 30	
						410	+	Mr. 30	
						420	−		
						434	−		
						349	−		

* Numbers 346, 404, 406, 420, 437, and 445 were kept in the greenhouse all winter; the others had been in the cold frame for from one to three months.

† All available plants having sori in the spring of 1914 were inoculated on the questionable assumptions that they would be more susceptible and that the mycelium is annual in the cedar.

The table shows that of the eleven cedars not having sori in 1914 five which were not inoculated developed no sori in 1915. Six were inoculated and four of them bore sori in 1915. Ten plants had sori in 1914 and all of these were inoculated, seven of them producing teleutospores in 1915. The first to show infection had been put in the cold frame October 29 and was brought in December 9. Two sori were discovered January 22. Eight more had been formed on this plant by March 12.

This teleutospore material was used in making further inoculations of *Amelanchier* and *Aronia* to check up the results obtained in 1914. Owing to the limited supply of spores on February 22, the sori of germinating spores were rubbed on the individual leaves of *Amelanchier*. Over infection resulted and many of the leaves were killed. The results of the experiments are given in Table III.

TABLE III

INFECTION EXPERIMENTS WITH SPORES FROM LEAVES OF POTTED PLANTS OF *Chamaecyparis* THAT HAD BEEN INOCULATED WITH *Roestelia transformans* IN 1914

No.	Trial host	Date inoc.	Spermogonia observed	Hypertrophy	Gall-horns	Aecidia appeared	Aecidia mature
425*a*	*Amelanchier intermedia**	Feb. 22	Mr. 6†				
427*a*	*Amelanchier canadensis**	Feb. 22	Mr. 6‡				
441	*Amelanchier intermedia*	Feb. 22	Mr. 6	Apr. 18	May 25	June 10	June 20
449	*Aronia arbutifolia*	Mr. 7	Mr. 18	Apr. 18§			
431	*Amelanchier canadensis**	Mr. 11	Mr. 22‡				
430	*Amelanchier intermedia*	Mr. 13	Mr. 24	Apr. 22	May 23	June 10	June 27
438	*Amelanchier intermedia*	Mr. 13	Mr. 26	May 5	May 20	July 6	July 25
439	*Amelanchier intermedia*	Mr. 13	Mr. 26	Apr. 20	May 25	June 24	June 30
442	*Amelanchier intermedia*	Mr. 25	Apr. 5	Apr. 20§			
443	*Amelanchier intermedia*	Mr. 25	Apr. 10	June 1	June 20	July 4	Aug. 2
444	*Aronia arbutifolia*	Mr. 25	Apr. 12	May 1§			
447	*Amelanchier Amelanchier*	Apr. 14	Apr. 23§				

* Leafy twigs were used in numbers 425*a*, 427*a*, and 431; all others were potted plants.

† Photographed and preserved as specimens.

‡ Infected leaves all killed.

§ No further growth.

There were ten different plants of *Amelanchier* including three species. Two numbers of *Aronia* were also used. The absence of failures may be attributed to the care taken in making the inoculations, and to the vigorous condition of the plants. These experiments (except number 447) were made before any teleutospore

material of *G. biseptatum* was brought into the greenhouse. It requires three or four weeks after aecidia make their first appearance on *Amelanchier* for them to reach their full length. Some of them appear to be unable to force their way out of the gall readily. The peridial cells loosen up so that spores are scattered long before the full growth of the peridium is attained (FIG. 24).

A large quantity of *G. biseptatum* was obtained at Lakehurst, New Jersey, on April 25, 1915. *G. fraternum* was not as abundant here as at Newfield, although scattering infections could be found on almost any *Chamaecyparis*.

Another set of cultures on *Aronia* and *Amelanchier* was made with *G. fraternum* from this locality. A summary of the results is given in Table IV.

TABLE IV

INFECTION EXPERIMENTS WITH *Gymnosporangium fraternum* FROM LAKEHURST IN 1915

Date of inoculation	Species of trial host	Number of plants	Positive results	Negative results
April 29	*Aronia arbutifolia*	11	9	2
April 29	*Aronia nigra*	5	5	0
April 30	*Aronia arbutifolia*	4	4	0
April 30	*Amelanchier intermedia*	1	1	0
April 30	*Amelanchier Amelanchier*	1	1	0
May 1	*Aronia nigra*	1	1	0
May 2	*Aronia arbutifolia*	8	6	2
May 2	*Amelanchier Amelanchier*	1	1	0
May 3	*Aronia arbutifolia*	6	2	4
May 3	*Amelanchier intermedia*	3	0	3
May 3	*Amelanchier canadensis*	1	1	0
May 16	*Aronia arbutifolia*	5	3	2
May 16	*Aronia nigra*	4	0	4
Totals	*Aronia*	44	30	14
	Amelanchier	7	4	3

Only a small supply of teleutospores was available May 3 and May 16. This in part accounts for the low percentage of infection on these dates. The *Aronia* leaves were rather old to expect good results. Three-fourths of the Aronias were infected and most of them developed a large number of aecidia. Four out of seven Amelanchiers were also infected. While *Amelanchier Amelanchier* was infected none of the plants of this species matured aecidia.

The question of determining whether the caulicolous form

(*Gymnosporangium biseptatum*) is capable of infecting *Aronia* was next considered. Small plants of *Aronia* and *Amelanchier* were in excellent condition at this time and the supply of teleutospore material from Lakehurst, New Jersey, was unlimited. The infection frame was used so that the different species of trial host could be subjected to the same conditions. Several branches bearing telia were hung about in the frame, and the plants were sprayed with large quantities of sporidia. Whenever Aronias were inoculated (except on April 15) one or more plants of *Amelanchier* were also used as controls. Table V also includes the results of experiments carried out in 1914. The teleutospore material used April 13–16 was obtained from Newfield.

TABLE V

INFECTION EXPERIMENTS WITH THE CAULICOLOUS FORM (*Gymnosporangium biseptatum*) IN 1914 AND 1915

Date	Trial host *Amelanchier*	Number of plants	Results +	Results —	Trial host *Aronia*	Number of plants	Results +	Results —
(1914)								
Je. 11	*A. canadensis*	1	1	0	*A. nigra*	3	0	3
" "	*A. intermedia*	1	0	1	*A. arbutifolia*	5	0	5
" "	*A. Amelanchier*	1	0	1				
(1915)								
Apr. 13	*A. intermedia*	1	0	1	*A. nigra*	3	0	3
" "					*A. arbutifolia*	1	0	1
" 15					*A. nigra*	3	0	3
" "					*A. arbutifolia*	10	0	10
" "					*A. atropurpurea*	1	0	1
" 16	*A. intermedia*	1	1	0	*A. nigra*	10	0	10
" "					*A. arbutifolia*	10	0	10
" 26	*A. intermedia*	3	3	0	*A. nigra*	11	0	11
" "					*A. arbutifolia*	8	0	8
" 29	*A. intermedia*	2	2	0	*A. nigra*	1	0	1
" "					*A. arbutifolia*	2	0	2
" 30	*A. intermedia*	6	6	0	*A. nigra*	1	0	1
" "	*A. Amelanchier*	2	2	0	*A. arbutifolia*	3	0	3
" "					*A. atropurpurea*	1	0	1
May 16	*A. intermedia*	11	11	0	*A. nigra*	7	0	7
" "	*A. canadensis*	2	2	0	*A. arbutifolia*	14	0	14
" "					*A. atropurpurea*	1	0	1
Total .	*Amelanchier*	31	28	3	*Aronia*	95	0	95

Some of the Aronias employed in making these tests were used over again for the second or even the third time. The first

sowings were made just as the first leaves were opening. When the last trials were made, May 16, there were still a few new leaves on each plant, but most of the leaves were too old perhaps to be susceptible to any rust. In order to determine this point *G. fraternum* was sowed on nine of the plants the same day (see Table IV) and three infections were obtained.

The variable length of time required for the development of the spermogonia demands that the plants should be kept under control conditions for at least a month. Arthur (2) reports sowing *G. biseptatum* on *Amelanchier canadensis* which did not develop spermogonia until after a period of twenty-five days. One of my cultures, No. 540, required thirty days. This was a shrub of *A. intermedia* about two feet high, which was transplanted from the garden April 28, after its leaves were full grown. *G. biseptatum* was sown on it April 30. The plant did not do well after it was transplanted; the leaves assumed what gardeners call the "sleepy condition." As no spermogonia were visible May 15, the plant was topped to save it. The remaining leaves soon regained their normal rigidity. On May 30 spermogonia began to appear in considerable numbers. Twenty-seven other infections were obtained on *Amelanchier*. Six showed signs of infection on the seventh day; four required eight days; ten showed in nine days; six in ten days; the one infected in the garden required thirteen days. The average incubation time of *G. fraternum* on *Aronia* and *Amelanchier* appears to be between nine and twelve days. Table VI contains a summary of these periods in some sixty experiments with *G. fraternum*.

TABLE VI

INCUBATION PERIOD OF *Gymnosporangium fraternum* ON *Amelanchier* AND *Aronia*

Incubation period, days	6	9	10	11	12	13	14	15	16	17	18	20	22
Number of plants: *Aronia*	3	12	15	5	4	4		1		1	3	1	1
" " " *Amelanchier*		1	1	4	4	3	1	1	1	1			

Gymnosporangium biseptatum (caulicolous form) will infect *Amelanchier* readily, but if it ever infects *Aronia* it must do so under different conditions from those prevailing in connection with the ninety-five attempts which I have made to bring it about.

My experiments of 1914, confirmed by those of 1915, also show that *G. fraternum* will infect *Amelanchier* about as readily as it will *Aronia*, producing on the *Amelanchier* hypertrophies and aecidia which may have furnished the basis for Peck's *Roestelia Ellisii* and which is without doubt now widely distributed in exsiccati under the name *R. Botryapites*.

Leaving aside the question of the accuracy or thoroughness of my experiments in attempting to infect *Aronia* with *G. biseptatum* the other cultures show that the foliicolous form on *Chamaecyparis* occurring so abundantly at Newfield and Lakehurst, New Jersey, is the *Gymnosporangium* connected with the well known *Roestelia transformans*.

GENERAL DISCUSSION

The color of the gall on *Aronia* produced by *Roestelia transformans* is commonly described as red or brownish. To quote from Peck (**15**): "Subiculum much thickened, produced into tufts of crowded subcylindrical or cornute processes, red or brownish, sometimes transforming an entire leaf."

I have noted above that the galls in my cultures remain perfectly green long after the aecidia are mature, and turn brownish only when old or after much exposure to weathering.

In 1875 Peck (**16**) described *Roestelia Ellisii*, collected by Ellis on leaves of *Amelanchier* at Newfield. Peck's description might well have been drawn from the form which I have obtained on *Amelanchier* by inoculation with *Gymnosporangium fraternum*: "Spots yellow, red or brown; subicular projections clustered or scattered, ovate, greenish, or yellowish; peridia cylindrical, single at the apices of projections, the laciniae remaining united at the apex, the cells linear, subflexuous, smooth. . . . This species is related to *R. transformans* Ellis, from which it differs in its paler, shorter, and differently shaped subicular projections, the smooth cells of the peridia, and the apically united laciniae." I have pointed out that in *R. transformans* on *Aronia* the apical peridial cells remain united, falling off together, and that the color of the galls varies with age. Peck could not have known of *R. Botryapites* or had it in mind when he described *R. Ellisii* for all subsequent writers have considered them identical on the basis of the "smooth flexuous cells," and the form of the galls on the host.

The galls of "*Gymnosporangium fraternum* on *Amelanchier*" are at first small wart-like growths, somewhat flattened or depressed at the center (FIG. 20). Ten or twelve weeks after inoculation the pit disappears and the gall begins to elongate, becoming ovoid (FIG. 21). The apex is marked by several rounded prominences (FIG. 25). There are no such fluted collars visible on the galls on *Aronia*. Thaxter (**20**) and Arthur (**2**) report that it requires from four to five months for the complete development of *Roestelia Botryapites* on *Amelanchier*. My records show that it takes about the same time for *Gymnosporangium fraternum* on *Amelanchier*, while on *Aronia* the aecidia mature six or eight weeks after inoculation.

Of the galls produced on *Amelanchier* when infected with *G. biseptatum* Farlow (**4**) says: "Although the peridia are not yet ripe there can be no doubt that the species is *R. botryapites*, as the tubercular swellings produced can not be mistaken for those of any other species known in this country."

I have shown that *G. fraternum* produces an aecidial form on the *Amelanchier*, which resembles very closely the aecidium known as *Roestelia Botryapites*, proved to be connected with *G. biseptatum*. It would be of no consequence whatever to draw conclusions as to the relationship of these two *Gymnosporangia*, based on even the most critical examination of the existing exsiccati of *R. Botryapites* which have all been collected in the field. There could be no assurance that two collections bearing the same number had the same origin. The spots on two leaves in the same package or even two spots on one leaf may have originated from two different teleutospore forms, one from the caulicolous, the other from the foliicolous form. This question can be attacked to greater advantage when a more extended opportunity has been afforded for a comparison of the various stages in their development, side by side on the same plant, of these two aecidia grown under controlled conditions. There are, however, certain hypotheses that may well be stated here with considerations *pro* and *con*.

It is possible that *G. fraternum* and *G. biseptatum* are two distinct species, as it happens, having on *Amelanchier* aecidia much alike. The following points support such a view: (1) the absence

of spores with more than two cells in the sori of *G. fraternum*, and the overwhelming predominance of three- to six-celled spores in *G. biseptatum;* (2) leaves of certain marked cedar trees at Newfield, to my knowledge, have borne sori of *G. fraternum* in the spring season of three years, the first being in 1911, with no indication of there being in the process of formation the fusiform swellings characteristic of *G. biseptatum* on any of the branches in 1913–1915; (3) it is possible to infect both *Aronia* and *Amelanchier* with *G. fraternum*, while *G. biseptatum* regularly infects *Amelanchier* only, so far as known at present; (4) we may have here a case similar to that described by Long (11). The two rusts, *Puccinia Ellisiana* and *P. Andropogonis* have the common teleutospore host *Andropogon*. The aecidial stage of the former is found on *Viola*, that of the latter on *Pentstemon*. Starting with aecidiospores on the violet and going back through the *Andropogon* he is able to infect *Pentstemon* very easily; but when he begins with *P. Andropogonis* on *Pentstemon* he finds that it is much more difficult to infect the violet. He believes that *P. Ellisiana* is continually passing over from the violet through *Andropogon* to *Pentstemon* by natural infections, in which case *P. Andropogonis* is being created over and over again. Once on the *Pentstemon* the rust is probably unable to get back in nature to the violet and therefore becomes fixed as a new form of the old species, *P. Ellisiana*. In addition to the marked changes in the aecidium which I have previously mentioned, Long also finds that the uredospore characters are modified by changing the regular sequence of hosts. *Gymnosporangium fraternum* being able to infect both *Aronia* and *Amelanchier* would correspond to *Puccinia Ellisiana; G. biseptatum*, so far as known being confined to the aecidial host *Amelanchier*, is the new form. In other words, the changes wrought in the morphological characters of *G. fraternum* during its life on *Amelanchier* would be reflected as physiological changes to such an extent that the fungus on going back to the *Chamaecyparis* becomes perennial in the tissues of the branches where further morphological changes are induced. (5) Cedars inoculated by me with aecidiospores of *Roestelia transformans* in July developed sori of *G. fraternum* the following spring, while controls (not inoculated) did not. Dr. E. W. Olive transplanted a small cedar from Newfield to the

grounds of the Brooklyn Botanic Garden April 19, 1914. This cedar bore a witch's-broom of *G. Ellisii* and many leaves showed sori of *G. fraternum*. Dr. Olive has informed me that although sori of *G. Ellisii* have appeared this spring, no *G. fraternum* has been found. This, so far as it goes, suggests that *G. fraternum* is annual.

Against the first of these arguments we have Farlow's statement that the number of cells in the spores of *G. biseptatum* varies according to the size of the branches upon which sori develop—the smaller the branches the greater the number of two-celled spores.

As for the second point it should be remembered that only two converse infections have been reported in connection with this genus. Arthur (1) reports that it requires only one year to complete the development of *G. clavipes* on the common juniper. Plowright (17) shows that *G. clavariaeforme* needs two years. These authors do not state the length of time previous to these experiments the junipers had been under observation so as to preclude the possibility of natural infections. To cite a case in point: a seedling *Chamaecyparis* about four inches high bearing a dozen sori of *G. Ellisii* was brought in from Newfield in May. A month later it was difficult to locate with certainty the region infected. Heald (7) was unable to infect the red cedar with the common apple rust. It is plainly as yet entirely uncertain how long a time elapses between inoculation and the formation of the spindle-formed distortions by *G. biseptatum*.

The behavior of known biological species of other rusts is such as might account for the difference in the susceptibility of *Aronia* and *Amelanchier* to infection by *G. fraternum* and *G. biseptatum*.

Having determined the facts regarding the infection limits of *G. fraternum* and *G. biseptatum* in connection with *Aronia* and *Amelanchier*, the most difficult part of the work still remains to be accomplished if a relationship between the two species of rust is to be established. We must know, first, whether "*G. fraternum* on *Amelanchier*" (*Roestelia transformans?* on *Amelanchier*) goes back to the cedar as *G. fraternum* or as *G. biseptatum* or as both; second, does *G. biseptatum* on *Amelanchier* (*Roestelia Botryapites* on *Amelanchier*) go back to the cedar and reappear as *G. bisepta-*

tum or as *G. fraternum*, or as both. We must also have further confirmation of the experiments recorded above in connection with converse inoculations of the cedar with *G. fraternum* on *Aronia* (*Roestelia transformans* on *Aronia*). Experiments bearing on these points are under way.

COLUMBIA UNIVERSITY,
DEPARTMENT OF BOTANY

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Explanation of plates 28 and 29

FIGS. 1, 3, 13–19, 22–25 from microphotographs taken with a binocular microscope camera, magnifications given under each explanation.

FIGS. 2, 4–12, 20 and 21 from photographs, natural size. FIGS. 26–43 from drawings made with aid of camera lucida, and magnified about 400 diameters.

PLATE 28. *Gymnosporangium fraternum* on *Aronia*, *Amelanchier*, and *Chamaecyparis*

FIG. 1. Sorus on leaf of *Chamaecyparis thyoides;* photographed April 16. × 5.

FIG. 2. Two sori in swollen condition, spores germinating June 3, nearly two months after leaves were collected and dried. Natural size.

FIG. 3. Small leaf of *Aronia nigra* showing group of spermogonia. × 3.

FIGS. 4–6. A leaf of *Aronia arbutifolia* from No. 203*b* (see Table I) showing various stages in the development of basal hypertrophies, horn-like galls, and aecidia. Fig. 4 photographed May 27; Fig. 5 same leaf June 5 with full grown galls; Fig. 6 side view of the same leaf June 20. Natural size.

FIG. 7. Growing point of twig of *Aronia nigra* one month after inoculation. Photographed May 22. Natural size.

FIG. 8. The same twig July 22. The leaves on the lower part of this twig had fallen off early in June, but the gall remained dark green until killed by insects. Natural size.

FIG. 9. Twig of *Aronia nigra* with large gall which later bore many aecidia. June 15. Natural size.

FIG. 10. Leaf of *Aronia nigra* much transformed; basal hypertrophies not noticeable. Natural size.

FIG. 11. Small leaf of *Aronia arbutifolia* infected at both edges; aecidia matured June 24. Natural size.

FIG. 12. Small leaf of *Aronia nigra* not distorted by the fungus. Natural size.

FIG. 13. Tip end of leaf of *Aronia arbutifolia* bearing several horn-like galls. × 3. Compare with FIG. 22, the same fungus on *Amelanchier intermedia*, which is also magnified three times.

FIGS. 14–19. Stages in the growth and dehiscence of a peridium; FIG. 14 the peridium just appearing, very sharp pointed; FIG. 15 the same four days later showing that dehiscence begins at a point considerably below the apex; FIG. 16 the dehiscence is complete, but the apical portion is still intact; FIG. 17 another aecidium from which the apical portion, shown in FIG. 19 has just fallen off naturally; FIG. 18 a long peridium from *Aronia nigra*. × 7.

FIG. 20. Leaf of *Amelanchier intermedia* showing typical appearance of clusters of wart-like galls, slightly pitted at this stage. Compare with FIGS. 4 to 13 of the same fungus on *Aronia*. Natural size.

FIG. 21. Leaf of *Amelanchier intermedia*, galls further advanced and nearly full grown. Slightly reduced in size.

FIG. 22. Portion of the same leaf two weeks later, showing the characteristic knob at the end of each gall; one peridium well out. × 3. Compare with FIG. 13. × 3.

FIG. 23. One gall from the leaf shown in FIG. 21. The knob at the end of the gall is better shown in FIG. 25. × 7.

FIG. 24. Gall with aecidium from leaf of *Amelanchier intermedia;* the lacerations are plainly visible although the peridium has just begun to appear; spores have already been shed in considerable numbers. × 7.

FIG. 25. Gall from leaf shown in FIG. 21; the striations on the peculiar growth at the apex of the gall are visible. Compare with FIGS. 13 to 18 which show that no such structure is formed when the fungus is on *Aronia*. × 10.

PLATE 29. *Gymnosporangium fraternum*, except FIGS. 31 and 32. Magnified 400 diameters

FIGS. 26–30. Teleutospores of *Gymnosporangium fraternum;* Fig. 26, the pedicel is much swollen and the collar is distinctly visible; FIG. 27 shows that the germ pore may be at the apex of the upper cell; FIG. 28 germ pores near the septum.

FIGS. 31, 32. Two-celled teleutospores of *G. biseptatum*.

FIGS. 33–38. Various stages in the germination of spores and formation of promycelium and sporidia of *G. fraternum*.

FIGS. 39, 40. Germination of sporidia and formation of secondary spores.

FIG. 41. A peridial cell from *G. fraternum* (*Roestelia transformans*) on *Aronia*.

FIG. 42. Spore from the same aecidium.

FIG. 43. A peridial cell from *G. fraternum* on *Amelanchier*.

INDEX TO AMERICAN BOTANICAL LITERATURE

1912–1915

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material.; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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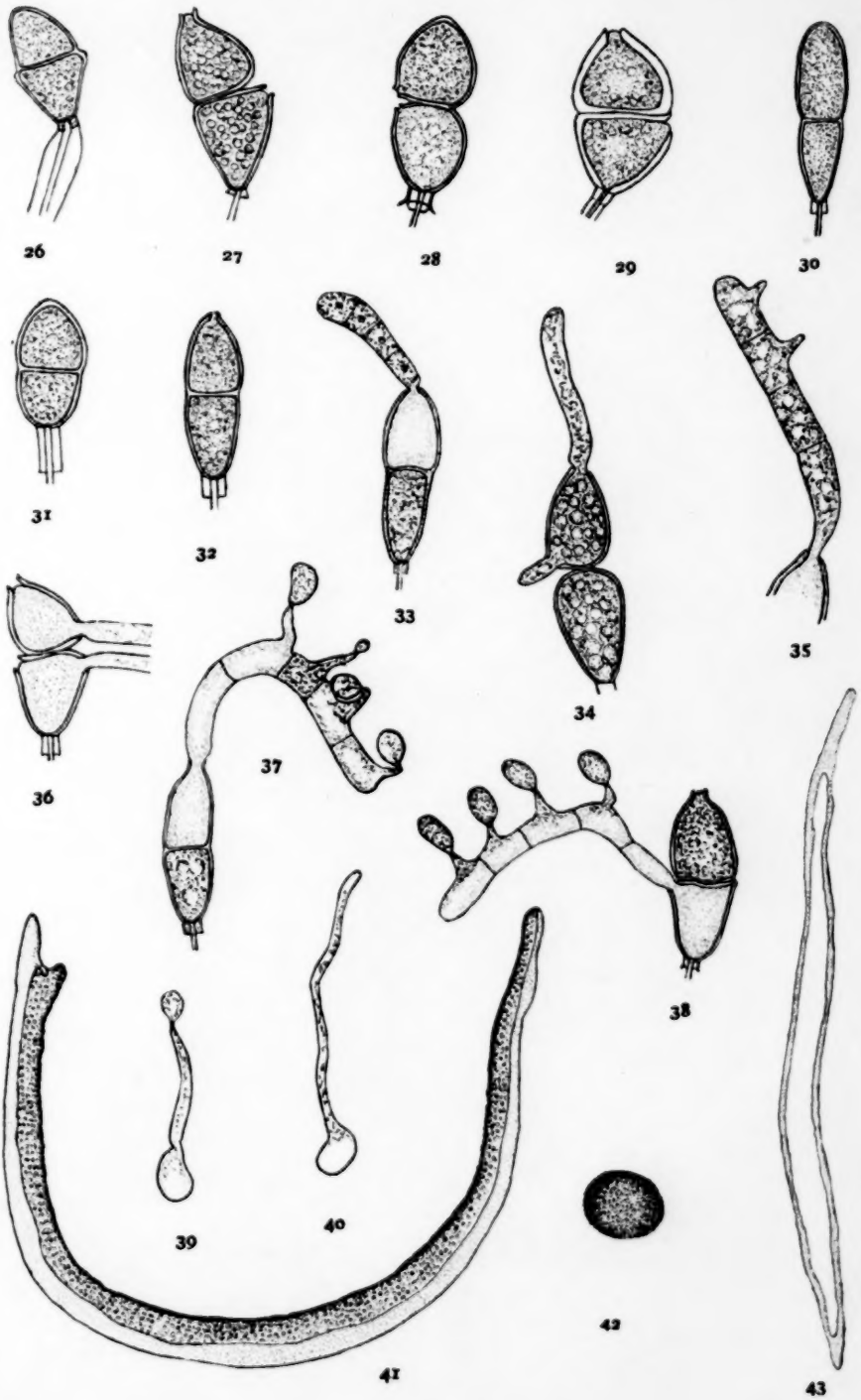
DODGE

GYMNOSPORANGIUM



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